THE
HOME TEACHER

A CYCLOPÆDIA OF
SELF-INSTRUCTION

EDITED BY

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ENGLISH LITERATURE.—CHAPTER IV.

CHAUCER'S LIFE AND WORKS—CANTERBURY PILGRIMS—LYDGATE AND OCCLEVE—PROSE WRITERS: PECOCK, FORTESCUE, MALORY, CAXTON.

RALPH HIGDEN, in the middle of the fourteenth century, distinguished three forms of English speech—Southern, Middle, and Northern. There were real grounds for this statement. In pronunciation, vocabulary, and grammatical inflexions there were differences in the habitual language of these parts which justified Higden's clear-sightedness. The lyrical ballads of Minot, and the grave homiletics of the Hampole hermit, both belong to the Northern and harsher dialect. To the East Midland the great romance of "Alexander" belonged, as did also Robert Manning of Brunne's "Handlying Sinne." This Lincolnshire bard has been styled by T. L. K. Oliphant "the patriarch of the New English." Certain it is that in the transition of speech from Saxon to Shakspearian English the Midlands have exerted great influence. But the Father of English Poetry, a title universally recognized as Chaucer's own, was a Southern. He is "our Helicon's first fountain stream, our morning star of song." In his works there is, indeed, written for our learning—

"Enough, both small and greate,
Of storial thing that toucheth gentilesse,
And eke morality and lovelinesse."

He is a man so shrewd, graceful, and humorous; so manifold, genial, and broad; so sound in morals; so rich in wisdom; so prudent yet unprudish; in taste so true; so wise and solid in character; so firm in his hold on the business of life; so real in his apprehension of all that marks man's life out as worthy of interest—goodness and godliness—that he is in himself an epitome of literature. The infinite variety of changeful life is in his poems. In them the England of Edward III. and Richard II. is photographed for ever. He welds Saxon and Norman words into oneness of power and purpose, as events had welded Saxon and Norman into unity of nationality and life. The English language, not by act of Parliament only, but by the might of a poet's mind, was enfranchised, set free in court, school, and public place. Living in a stirring and brilliant period, he added the lustre of poetry to the glory of England's arms and the renown of the legislation of "the good Parliament," while he brightened for ever the speech of England with the splendour of song.

Geoffrey Chaucer was the son of John Chaucer, vintner, Thames Street, London, and of Agnes his wife. The date of his birth is uncertain. Though by Speght it is given as 1328, by some modern critics 1340 is regarded as a more probable date. The latter is inferred from the fact that in a deposition made by him in a lawsuit, in 1386, Chaucer declares formally that he was forty years of age and upwards, and had borne arms for twenty-seven years. Though Gower speaks of him in 1392 as "now in his days old," Occleve calls him "father reverent," and Leland tells us "he lived to the period of gray hairs, and at length found old age his greatest disease," while Chaucer himself says that he is grown old and unlusty, yet 1340 seems to be now regarded as the more probable birth-date. No traditions of his early years have reached us. Geoffrey Chaucer, as a boy, went no doubt to some school in the neighbourhood of his father's hostelry, and he not improbably often replenished the citizens' cups from the draught-wine in the cellar. Leland thought that the poet had studied both at Oxford and Cambridge. His father appears to have had a connection with the court of Edward III., and Chaucer probably attended that king, and his Queen Philippa, to Flanders and Cologne as a page. In April, 1357, he appears to have entered as an attendant servitor into the service of Elizabeth, wife of Lionel, duke of Clarence, third son of Edward III., for "an entire suit of clothes, consisting of a paltock (a short cloak), a pair of red and black breeches, with shoes [was then] provided for Geoffrey Chaucer," and several other entries concerning supplies for him appear in some fragments of the household accounts of the princess for that year. As court lacquey he may have been present at the brilliant court entertainment called "the Great Feast of St. George's," given in 1358 by Edward III. to John the Good, king of France, and his sister; Joan, wife of David II. of Scotland; the King of Cyprus; the queen-mother Isabella, and others. It was in such service that likely-looking lads learned courtesy, the practise of arms, some arts of usefulness, and a knowledge of affairs. Here he saw life in its various phases, and observed the habits of the most distinguished men and women of that age. As a young man of nineteen he, having joined the army of Edward III., took part in the invasion of France, 1359, was taken prisoner at the siege of Rhétiers, and in 1360, on the king's paying £16 of ransom for him, he was set free under the great peace of Bretigny. He was appointed, in 1367, a gentleman of the bedchamber, to which a life-pension of twenty marks per annum was attached, and in the same year he married Philippa de Roet, the daughter of a Flemish knight, Sir Payne de Roet, Guienne king of arms. In 1366 Philippa Chaucer, the queen's namesake and attendant, had conferred on her by her mistress a pension of ten marks a year, and on his consort's death, 1369, Edward III. reconfirmed the grant. Her sister Catherine became the third wife of John of Gaunt, who was Chaucer's life-long patron. During the next ten years he was engaged in seven diplomatic missions. In one of these he was sent (1373) to Italy; while there he visited Florence, Genoa, and Padua, and at Arqua met Petrarch, from whom, it is said, he heard the story of "Patient Griselda." He was, in 1374, appointed comptroller of the customs and subsidy of wools, skins, and leather, in the port of London; received a pension of £10 per annum for life from the Duke of Lancaster; and on 10th May of that same year leased a house above Aldgate from Adam de Bury, mayor of London.

In 1375 he was made custodier of the lands and person of Edmond Staplegate of Kent, for which he received fees of wardship and marriage. Next year he was, with John Burley, employed in the service of the crown, and was associated with Sir Thomas Percy (afterwards Earl of Worcester) in a secret mission to Flanders. He was also co-agent with Sir Richard Sturry and Sir Guichard d'Angle (Earl of Huntingdon) in framing a treaty of peace with Charles IV., and negotiating in 1378 a marriage between Richard, prince of Wales, and Mary, daughter of Charles the Wise. On this latter mission he was despatched again, after the accession of Richard II. On his return he was sent to Lombardy on state affairs, and then he appointed his fellow-poet, John Gower, to be trustee for him in all legal affairs. In recognition of these services Chaucer was made, in addition to his former office, comptroller of the petty customs of London, with the privilege of appointing a deputy. As a knight of the shire of Kent, Chaucer sat in the Parliament of 1386; but having displeased the Earl of Gloucester he was removed from his offices, and fell into poverty. His wife died in 1389. On the re-attainment of power by the Lancastrians, Chaucer was chosen clerk of the king's works at Westminster and Windsor. Not long afterwards he was superseded, and required to fall back on some small pensions for subsistence. For a time he was apparently in distressed circumstances and in ill-health. He obtained, 1394, a grant of £20 per annum from Richard II., and four years thereafter letters of protection from suit or arrestment were issued in his favour. Within four days after his accession, Henry IV. (Bolingbroke), touched by the quaint humour of the "Complaynte of Chaucer to his Purse," doubled his pension. On Christmas, 1399, he signed a lease for fifty-one years for a house in the garden of the chapel of St. Mary, Westminster, and there on 23rd October, 1400, he died, leaving one son, Thomas, who ultimately became very wealthy, and was elected Speaker of the House of Commons. His other son, Lewis, had long predeceased him. His daughter married De La Pole, duke of Suffolk.

Such are the main facts of the external life of the poet, whose gracious and happy nature has given him so lofty a place among the producers of imaginative literature. Dryden characterizes his writings as "a perpetual fountain of good sense." Wholesome thought and Horatian good humour, combined with living seriousness and loving serenity, characterize his productions. They are of all sorts, from rondels

and ballads to translations and transcripts, and from these to fine clear-sighted realizations of the world around him and the people who moved through its scenes. In the rich yet easy rhythm of a sympathetic nature he has immortalized the creatures of a day who had the happiness to live in the eye-glance of the poet.

Of the poems of his prentice-time, we need only make mention. Few except zealous students of England's early literature will care to read through the long translation of the allegorical "Romaunt of the Rose"—abbreviated and improved though it has been by Chaucer. "The Assembly of Fowles" or "Parliament of Birds"—an English setting of a *fabliau* or metrical tale, of which there are three forms, "Huéline et Eglantine," "Le Jugement d'Amour," and "Florence and Blancheflores"—though glorifying St. Valentine's Day, and having many fine lines in its hundred heptastichs, would scarcely engross general attention. "The Boke of the Duchesse," on the death of Blanche, duchesse of Lancaster, and partly founded on Machault's "Dit de la Fortune Amoreuse," is authenticated by mention of it as his in the prologue to the Man of Laws' tale:

> "In youth he made of Cyex and Alcyone."

It has some fascinating verses. Chaucer's A B C is a version of De Guilleville's alphabetic exposition of "The Prayer of Our Lady." Of the poems of his maturer years, "Troilus and Cressida" is, for the most part, a translation from Boccaccio's "Filostrato." The "Court of Love" is the most musical of Chaucer's metrical works. "The House of Fame" is a vision of the intellectually glorious, and is the best evidence of Chaucer's discursive powers, singular humour, and wide reading. Of the later poems, "The Legende of Goode Women," celebrating the nine saints and martyrs of love, the materials are chiefly taken from Ovid. But it is in the "Canterbury Tales," that best of all reproductions of the life of the fourteenth century, that the genius of Chaucer shines out most resplendently. It is a gallery of portraits pre-eminently matchless for truth, clearness, and reality.

The setting of the "Canterbury Tales" is dexterously arranged. At the Tabard Hostelry, situated in the High Street, Southwark—then the great outlet from London to the southern ports, and the course of the main highway leading thence into the divergent roads of Surrey, Sussex, and Kent—in the month of April, Chaucer "lay ready to wenden" on a pilgrimage to Canterbury, together with "nine and twenty in a company of sundry folk," who also found entertainment under the roof of Harry Bailly,* the host, "a seemly man." The poet soon got into fellowship with all "that toward Canterbury wolden ryde," and he considers it right to tell us who, and of what degree, each was. He begins by describing a knight, "evere honoured for his worthinesse," who had been at fifteen battles.

> "And tho' that he was worthi he was wyse,
> And of his port as meek as is a mayde. . . .
> He was a veray perfit gentil knight."

He was accompanied by his son, about twenty years of age, as his squire. The latter was

> "A lovyere and a lusty bacheler, . . .
> Embrowded was he, as it were a mede,
> All ful of fresche floures, white and rede,
> Syngynge he was or floytynge all the day,
> He was as fresche as is the month of May . . .
> Schort was his gowne with sleeves long and wyde . . .
> Curteys he was, lowly and servisable."

A yeoman acted as the knight's servant. He was "clad in coate and hood of greene."

> "A nuthead had he with a broun visage,
> Of woodcraft could he well all the usage."

A smiling nun, a prioress, "cleped Madame Englentyne, highly accomplished, though her French was rather of Stratford-atte-Bowe than of Paris, of pleasant manners, observant of table-etiquette," was there. She was full statured, seemly in dress, "hire eyen, greye as glas," gleamed from under a fair forehead almost a span broad, her nose was well shapen, her mouth full small, soft, and red. Along with her was another nun and three priests, with nothing apparently remarkable about them. Next a monk—"a manly man, to ben an abbot able"—is described. He had many a dainty horse, was fond of hunting, self-indulgent, not given to reading, and his vows sat lightly on him.

> "I saw his sleeves purfled at the honde
> With *grys*, and that the finest of the lande; [grey fur]
> And for to festen his hood under his chin
> He had, of gold y-wrought, a curious pin;
> A love-knot in the greater ende there was,
> His head was bald, and shone as any glas,
> And eke his face as he had been anointe,
> He was a lord ful fat and in good point,
> His eyen steep and rolling in his head."

A friar—a wanton and a merry, a limetour, *i.e.* one licensed to beg alms within a certain district, very fair-spoken, and peculiarly adroit in managing all sorts of people—is thus portrayed:—

> "His tippet was aye *farsed* ful of knyfes, [stuffed]
> And pinnés for to give fair wifes. . . .
> His neckké white was as the fleur-de-lys. . . .
> Thereto he strong was as a championn,
> He knew the taverns well in every town. . . .
> Of double-worsted was his semi-cope,
> That rounded as a bell out of the presse.
> Somewhat he lispéde for his wantonesse,
> To make his English sweete upon his tongue,
> And in his harping, whan that he had sunge,
> His eyén twinkled in his head aright,
> As don the sternés in the frosty night."

A merchant who traded "betwixt Middleburg and Orwell," the river on which Ipswich and Harwich are situated, thereafter stands before us "with a forked beard," dressed in motley, having a Flander's beaver-hat upon his head, and his feet encased in boots "clasped fair and fetysly." He was shrewd on Change.

> "This worthy man full well his wits *bisette*, [busied]
> There wist no man that he was in debte,
> So estately was he of governance,
> With his bargains and his *chevysaunse*." [agreement]

Amongst the number, "a clerk there was of Oxenford also," whose horse was lean; himself lean, hollow-eyed, and threadbare, unworldly, and therefore unbeneficed.

> "For him would rather have at his bedde's head,
> Twenty books, clad in black or red,
> Of Aristotle and his philosophie,
> Than robes rich or fiddle or gay psalterie. . . .
> Of studie he took most care and most heed,
> Not one word spake he more than was need."

A sergeant-at-law, cautious and wise, well employed and well paid, forming a contrast as he stands in his homely coat of mixed stuff, fastened with a silk girdle:

> "Nowhere so busy a man as he there *n'as*—[*was not*]
> And yet he seeméd busier than he was;"

and a sanguine complexioned franklin, whose beard was white "as is the dayesye," so much of a gluttonous man and a winebibber that he "was Epicurus' owne sonne," who had held several public offices, are next introduced. To them succeed

> "An haberdasher and a carpenter,
> A webbe, a dyere, and a tapiser, . .
> Well seemed each of them a fair burgess,
> To sitten in a guildhall on a dais,
> Everyone for the wisdom that he can,
> Was shapely for to be an alderman."

They had with them a canker-skinned cook, who liked a draught of London ale. Besides being a capital hand at making "blankmanger" (blanc-mange),

> "He could roast, and seethe, and broil, and frie,
> Makin *mortreux*, and well bake a pye." [soup]

* A Harry Baily or Bailly, who was the keeper of a hostelry in Southwark, sat as the representative of that borough in the Parliaments of Edward III. and Richard II.

"A shipman was there," also from the west—perhaps Dartmouth. Though

> "Of nice conscience tooke he no keepe, . . .
> He knew all the havens, as they were,
> From Gothland to the Cape of Finisterre,
> And every creek in Britayne and in Spaine!
> His barge y-cleped was the Magdelaine."

Of a "doctor of physic" we have an exquisite portrait:—

> "He knew the cause of every maladie,
> Were it of heat or cold, or moist or drye, . . .
> His studie was but little on the Bible,
> In sanguine and in pers he clad was all,
> Lined with taffeta and with sendal, . . .
> . . . Gold in physic is a cordial,
> Therefore he loved gold in special."

A goodwife of Bath, next presents herself. She is "some deal deaf," clever, vain, daintily dressed.

> "Bold was her face, and fair and red of hue,
> She was a worthy woman all her life,
> Husbands at church door haddé she five, . . .
> And thrice had she been at Jerusalem, . . .
> Gat-toothed was she soothly for to say."

"A poor parson of a town" is thereafter limned. He is a good man, rich in holy thought and work—

> "He was also a learned man, a clerk
> That Christe's gospel trewely wold preach,
> His parishens devotely would he teche.
> Benigne he was and wonder diligent,
> And in adversitie ful patient. . . .
> Wide was his parishe and houses far asunder,
> But he ne lafte not for raine ne thunder,
> In sicknesse nor in mischief to visite
> The farrest in his parish—moch and lite
> Upon his feet and in his hand a staff.
> This noble example to his sheepe he gaf,
> That first he wrought and after that he taught. . . .
> He waited after ne pompe ne reverence,
> Ne maked him a spiced conscience,
> But Christe's lore and his apostles twelve
> He taught, and first he followed it himselve.
> With him there was a ploughman—his brother,
> That had y-led of dung ful many a fother,
> A trewe swinkere and a good was he,
> Living in peace and perfect charity.
> God lovede he best, with all his true herte
> At all times, though him gamede or smerte,
> And thenn his neighbour righté as himselve. . . .
> There was also a reeve and a millere,
> A sompnour and a pardoner, also
> A manciple—and myself—there were no mo."

These different persons met at the Tabard Inn under the host—in whose portrait many critics believe Chaucer has sketched for us himself. We are inclined rather to think that a good many of the main traits are those not of the poet, but of his father the vintner. It runs thus:—

> "A seemly man our hoste he was withalle,
> For to have beene a marshall in a halle;
> A large man he was, with eyen steepe,
> A fairer burgeys was there none in Chepe;
> Bold of his speeche, and wise, and well y-taught,
> And of manhoode he lackede him naught,
> Eke thereto he was righte a merrye man."

In his mirth, among other things, he proposes that, to lighten the way, they should each tell two stories on the road to Canterbury, and two on the return journey. As there were thirty-two pilgrims in all, and each was to tell four tales, provision was made in the framework for 128 stories altogether. Of these, however, only twenty-four remain. The whole plan of the work was never completed, and it stands at the head of the "storial" rhymes of our literature a mighty fragment of a wonderful design. For the realization of such an elaborate production life was too short, and, perhaps, human imagination too limited. The proposed series of stories was not even "left half told," but what he has "committed to the care of time" is only excelled in its versatility and power of showing the "form and pressure" of life by that unsurpassable one who "first exhausted worlds and then imagined new." The prologue we may regard as pretty nearly complete. Part only of the journey to Canterbury is given; we have no account of the transactions at A'Becket's shrine, none of the homeward way or the tales that enlivened the return. We want, too, the epilogue, stating the changed relations of the pilgrims, the crowning of the prize story-teller, the jolly supper, and the separation of the singularly consorted company, of all which we had promise in the words:

> "And after will I telle of our voyage,
> And all the remnant of our pilgrimage."

In the prologue to "The Legend of Goode Women," the god of love says to the author—

> "Thou hast translate the 'Romaunt of the Rose,'
> And of 'Cresyde' thou hast sayde as the lyste."

His "queene, with the white corowne, clad in grene," says in Chaucer's defence—

> "He made the booke that hight 'The House of Fame,'
> And eke 'The Death of Blanché the Duchesse,'
> And 'The Parlement of Fowles,' as I guess,
> And alle the love of 'Palamon and Arcite,'
> Of Thebes, though the story is known lyte;
> And many a hymne for your holydayes,
> That highten balades, roundels, virilayes.
> And for to speak of other holynesse,
> He hath in prose translated Boëce,
> And made 'The Life' also *of Seynte Cecile;*
> He made also, gone is a great while,
> 'Origenes upon the Mandeleyne.'"

Chaucer is commanded by the queen of love to write the "Legende of Goode Women," and when it was finished to give it to "the queen on her behalf, at Eltham or at Shene." This queen was Anne of Bohemia, whom Richard II. married in 1382. It was his interest, at this time, to recall his best works, and this list authenticates several as being written prior to this date.

The first of the Canterbury Tales, the knight's, is a version of Boccaccio's "Thesseida," apparently the same as, or a revised form of, that which is noted in the foregoing lines as "Palamon and Arcite." The miller, somewhat drunken, characteristically tells one of those rough jesting tales which sin against the proprieties of home life. The reeve matches this with a *fabliau* taken from Jean de Bodes, of "Gombert and the Two Clerks"—a little whitewashed. The cook's tale at first appears to be of the same sort, but Chaucer seems to have bethought him—

> "A villany it were, thereof more to spelle,
> But of a knighte and his sonnes my tale I will forth tell,"

and replaces the story of a revelling London "idle apprentice" with the tale of "Gamelyn"—a portion of which has been incorporated in Shakspeare's play of "As You Like It." [This tale seems either to have been an early production or a copy from another author intended for adaptation.] The man of law, after referring to Chaucer's "Legend of Good Women," and mentioning most of the legends of Cupid it contains, selects from Gower's "Confessio Amantis" the story of "Pious Constance." From the same source the wife of Bath takes her "Legend of Florent." The tales of the friar and the sumpnour are quite dramatically introduced—the friar showing how a sumpnour by overgreed has his body gifted to the prince of darkness, and the sumpnour jesting as to how a friar could "distinguish and divide" among his twelve *confrères* a certain ill-flavoured presentation, "light as air," bestowed on him by a dying man, as that which would best show the respect in which he held the friar, and indicate the value he attached to his services. The clerk's tale is that of "Patient Grisilda," taken from a Latin version by Petrarch of the last story in Boccaccio's "Decameron," and turned most freshly into English. The merchant's tale is one of an old husband and a young wife, and the incompatibility of the ill-matched couple. The squire, to the regret of all time, has "left half told the story of Cambuscan bold." The franklyn's tale is taken from a Breton lay, of which Boccaccio has given two versions. "The Life and Passion of St. Cecilia," which Chaucer had noted as

one of his earlier poems, appears here as the second nun's tale, and forms an almost literal translation from the "Legenda Aurea" (Golden Legend) of Jacobus a Voragine. The canon's "Yeoman's Tale" is, like himself, rather informally introduced. It is an onslaught on the villany of alchemy. The doctor narrates the story of Virginia as given in Livy and Gower, as "a tale of some honeste mattere." The pardoner went to the "Cento Novelle Antiche" (No. 82) for his contribution to the amusement of the merry pilgrims. The shipman took Boccaccio's first narrative of the eighth day as his merry tale; and the prioress recounts one of the strange sweet stories of Asia in "The Christian Widow's Martyr Child." The host calls on the poet to give them some dainty thing, and he, burlesquing the perplexing prolixity of the *trouvères*, commences the rhyme of "Sir Thopas," but the host cuts short the metrical medley and demands a story of another sort. He then gives, in prose, a translation from the Latin of "Albertano de Brescia, the allegory of Melibœus and his Dame Prudence." The monk runs over "in mannere of tragedie" the fate of the great fallen from high estate, and is threatening to go on "from point to point, not a word would he faile" through the long catalogue of cases, when the knight impatiently interrupts him, and the host, as master of the proceedings, calls on the nun's priest to take up his parable and speak. This he does in "The Cock and the Fox," from the lays of Marie, a French poetess. The manciple's tale, which comes next, is out of Ovid, the transformation of the crow from white to black. The poor parson proposes to tell a merry tale in prose, but this really turns out to be a parable of pilgrimage on Jer. vi. 16, and is used

"To knit up alle this feast and make an ende;
And Jesu for his grace wit me sende,
To show you the way in this voyage,
Of thilke parfect glorious pilgrimage,
That has heaven celestial."

So the blood-warm life of England passes in panorama before our eyes, though five centuries have elapsed since the genial-witted poet penned his healthy strains. He shows the lusty, fleshly side of human nature, as well as the higher and holier spiritual temper which quickens man. He has a keen relish for all kindness, is honest and true, simple and social, delights in good living, and feels himself surrounded with the presence of heavenly God.

It is pleasant to note that one of the earliest of the prose products of English thought was one on "The Love and Right Use of Books," a theme which is ever renewed as literature increases the contents of its treasuries. Its author was Richard Aungervyle of Bury St. Edmunds, lord chancellor of England; its title, "Philobiblon." It commends wisdom, and books as the abode of wisdom; it advocates the preference of books to wealth or luxury, and that they should be bought eagerly, though with due caution as to worth and cost. It complains against degenerate clergy for neglect of books, and praises the clergy of a former time for their zeal in studying and making of books. It describes the nature and contents of books, incites to loving handling of them as having valuable souls within their too perishable bodies, details the delight of collecting books, and intimates his intention of devoting his collection to the service of scholars. It was written about 1330, first printed at Cologne 1473, at Paris 1500, in Oxford 1599, and a translation of it was produced by J. B. Inglis into English in 1832, and into French by M. H. Cocheris in 1856. Of the wise scholarliness which Richard of Bury commended, Chaucer was an eager disciple. He read many books and gleaned wisdom from them. He wrote many books, into which he put the results of much reading, and shrewd thought, and keen observation; and, like his own clerk of Oxenford, "gladly wolde he lerne and gladly teche." In the closing lines of his early poem, "The House of Fame," he, having heard that labour is required to find a place therein, says—

"Wherefore to study and rede alway
I purpose to do day by day."

In "The Parliament of Birds" he reflects on

"The lyf so short, the crafte so long to lerne;"

and speaks of his steady habit of seeking knowledge—

"Yt hapeth me in bookes ofte to rede . . .
Of usage olde, what for luste, what for lore,
Of bookes rede I ofte, as I you tolde,
For out of olde feldys, as men seyth,
Cometh all this newe corne fro yere to yere;
And oute of olde bookes, in good feythe
Cometh all thys newe science that men lere,
. . . and thus to rede I wol not spare."

So "out of olde bookes" he enriched the minds of his contemporaries, and enlarged the range of their intellectual vision by bringing under their ken the products of Latin poetry, middle-age scholasticism, Italian narrative, Norman *fabliaux*, Saxon folk tales, Cymric stories, and historic incidents, in every form of verse—rapid octosyllabic couplets, romance rhymes, ballad terns, heroic verse, and his own rhyme-royal, besides innumerable excellent experiments in rhythmic metre—and to each and all of them he gives a charm which brings them lovingly home, alike to heart and hearth, business and bosom.

Chaucer's English does not materially differ from that of our own times, only that syllables and letters which with us have been reduced to silence, or become obliterated, are melodiously vocal in his verse. There is also some difference in spelling and accentuation; but careful noting of his rhythm, and thoughtful perusal of his poems, soon sets these small matters right. The sweet graciousness and manifold felicities of his diction grow into a sort of charm pleasing to the ear and fascinating to the mind. It requires much study, but will well repay the care and trouble necessary; and the existence of the Chaucer Society is an evidence that his worth is found to reward the work expended in knowing the writings of him of whom Roger Ascham said, "I ever thoughte his sayings to have as much authority as either Sophocles or Euripides in Greek." Chaucer himself had a similar experience to ours in this matter, for he says:—

"I know that in formé of speech is change
Within a hundredth yeeré, and words *tho* [then]
That hadden price, now wonder nice and strange
Thinkké we them; and yet they spake them so,
And sped as well in love as men now do."

Chaucer was noble in person, modest in demeanour, beautiful in features, having a face full and smooth, a pale complexion, dark yellow hair, a long pointed beard, a large arched forehead, and bright eyes over which the lids drooped so that they seemed cast to the ground, looking meditatively as if they saw nothing, yet all the while seeing everything and remembering all.

The following description of Geoffrey Chaucer, which pretty nearly coincides with Occleve's portraiture, appeared in "Greene's Vision" in 1592:—

"His stature was not very tall;
Stout he was, his legs were small,
Hosed within a stock of red;
A buttoned bonnet on his head,
From under which did hang, I weene,
Silvered haires both bright and sheene;
His beard was white trimméd round,
His countenance blithe and merry found.
A sleeveless jacket large and wide,
With many plaits and skirte's *side* [long]
Of water[ed] chamlet did he weare;
A whittell by his belt he beare.
His shoes were *cornéd*, broad before. [peaked]
His inkhorne at his side he wore,
And in his hande he bore a booke,
Thus did this ancient poet looke."

John Lydgate was born in the village near Newmarket from which he took his name, about 1370. This good-humoured, bright-minded, and earnest monk was much impressed by the writer of the Canterbury Tales. He calls him "My Maister Chaucer," "chefe poete of Bretayne," "he that was of making, sovereigne."

"Whome all this lande of right ought to preferre,
Sithe of our langage he was the lode-sterre."

His "Storie of Thebes," drawn from the manipulated middle-age version of Statius' "Thebaid," is written as a tale told

by him when, after his sickness, he was on his way to Canterbury, and met Chaucer's pilgrims on the road. With them he supped, and to them he, at Boughton-under-Blean, obeyed Harry Baily's command, "Tell us something that draweth to effect." In the monk's tale Chaucer had spoken

"Of them that stood in great prosperitie,
And ys y-fallen out of high degré
Into miserie;"

and in the nine books of "The Falls of Princes," Lydgate—after enumerating the works of Chaucer and declaring his admiration of his verse—proceeds to emulate him, while recording the misfortunes of those who have fallen from high estate, and reads mankind a lesson thus:—

"Who climbeth highest on Fortune's wheele,
And soddenly to richesse doth ascende,
Ane unawares turne, afore scene nevere a dele,
When he least weeneth, maketh him descend;
Fro suche changes, who may him defend,
But they that be with povert not dismayede,
And can with little hold themselves apayede."

The matter of this book was taken from Boccaccio's "Instability of Earthly Fortune," through a French version made by Laurent de Premierfait, commended to the monk by Humphrey, duke of Gloucester, who was found murdered in bed, 23rd February, 1447. Lydgate's "Troy Boke," to which we alluded in a previous chapter (p. 197), is a versified translation of the "Historia Trojana" of Guido della Colonna, a poet and lawyer of Messina, whose fame among story-lovers was great. In "L'Envoye de Chaucer" to the clerk's tale of "Patient Griselda," that author had merrily counselled women not to give occasion to any one, by being patient and kind, to write a similar story of them,

"Lest Chichevache you swallow in her entraile."

Lydgate caught up the humour of the idea, and composed his "Bicorn and Chichevache," the former fat and sleek, fed on good and enduring husbands, and the latter skin and bone because she fed on good and patient wives. They were truly very scarce, for she complains:—

"It is more than threttie Mayes
That I have sought from lande to lande,
But yet one Grisseld never have I fande."

Ritson gives a list of about 250 poems attributed to Lydgate. He seems to have been a rhymer to order, and to have had such a power over verse as to have reduced it to mere manual mechanism. "A Life of our Ladye," written for Henry V.; a "Legend of St. Albans," composed by desire of the Abbot of Verulam; an "Encomium of St. Edmund of Bury," for his own monastery; a version of Makabir ("The Dance of Death"), explanatory of the frescoes on the north side of old St. Paul's; "The Churl and the Bird" (from a pamphlet in French); the ballad of "Jack Hare" (the drunkard); "The London Lickpenny," "on the little that can be got in this world without the money to pay for it;" and many other verses, are due to John Lydgate's versatile and active mind, and prove him to have been a man of wide sympathy, great cleverness, and mastery of metre.

Thomas Occleve, probably born at Hockcliffe in Bedfordshire, was a government clerk in the office of the Privy Seal, who required—in the covert courtesy of song—to dun his masters for payment of his dues. To his longest poem, addressed to Henry V., on "The Duty of Princes," a metrical translation of a work formerly ascribed to Aristotle, he has prefixed a lengthy introduction describing his hardship as a householder in the service of the state, by not getting his salary regularly paid. He deprecates the French wars of the hero of Agincourt, invokes Peace for favour to England, and insists that Christian sovereigns should fight only against the enemies of Christ, the sovereign of the soul. In it he complains—

"So is myne herte wo,
That the Honoure of th' Englysshe Tongue is dede,
Of which I was wont to have counsel and rede;
O maister dere and father reverent,
My maister, Chaucere! flowre of Eloquence,
Mirrour of fructuous entendëment,
O universal father in Science!" &c.

Occleve's "Misrule" is a warning to youth against folly, of great power and effectiveness; his "Poem and Roundel to Somer," Baron of the Exchequer, ingenuously asks him to be bounteous with seasonable summer supplies, "the lack of which is our great heaviness."

A name noted by Occleve, while recalling what "Holcot saith upon the book also of sapience," reminds us of the prose writers of this period, among whom was this Robert Holcot, a Dominican divine, teacher of theology at Oxford, distinguished for philosophic acumen and singular eloquence, commentator on Ecclesiastes, the book of wisdom, author of moralizations on histories, and essayist on "The Seven Sins," "The Immortality of the Soul," &c., books which, though written in Latin, seem also to have been popularized, at least as to their leading thoughts, in English. As Chaucer refers to Bishop Bradwardin, as one who can "boult" any difficulty "to the bren," we may notice his three books on "The Laws of God," for which the Pope honoured him as "the profound doctor." Bradwardin, who sprang from an old Chichester family, was a graduate of Merton College, and became professor of divinity and chancellor of the University of Oxford, as well as chaplain and confessor to Edward III., whom he attended during the wars in France. He was a distinguished mathematician and astronomer, and mediæval mathematical metaphysics and theology had few greater names than his. John of Gaddesden, also of Merton College, Leland calls "the light of his age." Under the title of "Rosa Anglica" he composed a treatise on medicine, setting up his English Rose against the "Medicinæ Lilium," *i.e.* lily of medicine, written by Bernard Gordon of Montpellier. Chaucer's doctor knew Averroes, Damascene, and Constantine—

"Bernard and Gatisden and Gilbertine,"

and probably the poet himself had met "the first Englishman employed at court as a physician," who was accustomed to mix English with his Latin.

Reginald Pecock, bishop of Chichester, Bradwardin's birthplace, had a rather remarkable career. He was a native of North Wales, born about 1390, and educated at Oriel College, of which he was elected fellow in 1417. Through the influence of Humphrey, duke of Gloucester, he was appointed Master of the College of St. Spirit and St. Mary, founded by the renowned "Whittington, lord mayor of London." The Pope made him Bishop of St. Asaph in 1444, and in 1447 he maintained in a sermon at St. Paul's Cross, London, that oversight and guidance, not preaching, were the functions of a bishop, for which he was obliged to defend himself before the Archbishop of Canterbury. This defence he enlarged under the title of "The Repressor of overmuch witeing (blaming) the Clergie" (1450). He spoke of the monkish preachers as "pulpit-bawlers," and became tolerant of Lollardism. In his zeal for popular enlightenment he composed many educational treatises. His activity and moderation led to persecution; his books were judicially examined and found to be heretical, and recantation or the stake was the judgment. He read his recantation at St. Paul's Cross before 20,000 people, and handed eleven quartos and three folios of his writings to the executioner, who consigned them to the flames. He died in solitary confinement, having the use of neither books nor writing materials, in Thorney Abbey, Cambridgeshire, in a year unknown, but probably 1460.

Sir John Fortescue, Lord Chief Justice of the King's Bench under Henry VI., was the author of different treatises in English and in Latin. In the former his "Difference between an Absolute and Limited Monarchy" is patriotic in spirit and popular in style. In the latter his "De Laudibus Legum Angliæ" (Praise of the Laws of England) has frequently been published; and it has been several times "done into English," once by Mulcaster, master of St. Paul's School, London. It was written to encourage and direct the Prince of Wales in his studies, to show the superiority of a constitutional over a despotic government, and to explain the difference between law duly enacted by statute and that dependent on the royal will. Aland says that for the latter treatise "all good men, and lovers of the English constitution, speak of him with honour;" and the ability and candour of

the former, Fuller thinks, "make him famous to all posterity." Both works have been recently re-issued and re-edited.

The quarry out of which the greatest and most popular poet of the present time has hewn the materials, not for the earliest essays of an apprentice in poetry only, but for some also of his latest and most finished works, can scarcely fail to excite interest. The "Morte d'Arthur," which, as Caxton says, "treateth of the byrth, lyf, and actes of the sayd King Arthur, of his noble knyghtes of the Round Table, their marvellous conquests and adventures," is that quarry. It is compiled from the French into English. As a romance of chivalry it had great success, and has powerfully affected the poetical conceptions of the English mind for generations. Malory's book was first printed by William Caxton in 1485. To Caxton England owes not only her early share in the advantages derivable from the greatest educative invention of these later ages—the art of printing—but a wise selection of excellent works, which he assiduously supervised, seeing through the press sixty-three books, some translations by himself, some original writings, and many prefatory introductions, so that he becomes entitled to a place in the history of English literature, not only as the earliest printer of books in England, but as a man of culture, talent, worth, and enterprise, "the first of so many" to whom we owe the kindling of genius, so that

"The fire was great—it made the nation light."

HISTORY.—CHAPTER V.

FIFTH ERA OF ROMAN HISTORY.

The admission of all the free Italian citizens to full participation in the privileges enjoyed by the citizens of Rome occasioned many changes in the polity of the state, and terminated in the subversion of the commonwealth by the appointment of a permanent chief magistrate with sovereign powers. This period of change is comprehended between the years of the city 665 and 703, when Julius Cæsar assumed sovereign power under the title of Dictator. During this period there is little growth of the Roman constitution. The delegated authority of the state resided in the senate. That body received ambassadors and resolved upon questions of peace and war. From the senate an appeal lay to the people; and, by the theory of the constitution, all new laws and all amendments upon old laws, after being discussed and reduced to proper form in the senate, were submitted to the people for their approbation. The senators were the heads of the patrician houses, and men of consular rank; and (latterly) such plebeians as had raised themselves to eminence in the state.

There were two kinds of popular assemblies. One consisted of *all* members of patrician houses, the other of plebeians only. The former had, however, merged into the meetings of *comitia*, from which it had never been entirely distinct. There being no distinct demarcation between the newer patricians from the more powerful plebeians, the meetings were composed of all classes of citizens; the plebeian element, however, greatly preponderated. In the comitia every Roman citizen was entitled to take a part; but the constitution of these meetings was of a very indeterminate, vague, and unorganized character. The decisions of these meetings were often incongruous, and the decrees of one were decried at the next. The worst characteristic of the decisions of these comitia was their partisan nature. Hence, while the deliberations of the senate were sagacious, consistent, and calculated to promote a rational, though arrogant and selfish policy, the deliberations of the comitia were passionate, fickle, narrow-minded, and redeemed only at times by glimpses of generous emotion and true intelligence.

The functions of a state must be delegated to officers, judicial, executive, and military. These duties are often incompatible, and their accumulation in the hands of one officer productive of serious mischief. In Rome the military department alone was adequately organized. But these different functions were not sufficiently separated—the same officer often discharged them all. The judicial functions were exercised sometimes by the senate, at other times by the comitia, and again by the consuls and proconsuls; but more permanently by the prætors, quæstors, ediles, tribunes, the arbiters appointed from the senators, and the *judices* appointed from the plebeians.

The law on which these tribunals framed their decisions was well developed and sharply defined. Only freemen were capable of holding property, and only Roman citizens could possess land-rights. The status of individuals, the distinction between freemen and slaves, between citizens and non-citizens, men of mature years, females, and pupils, were also fully and accurately defined. Even the personality of a corporation was perfectly familiar. The law of marriage—and the difficulty to be apprehended by the non-recognition on the part of the patricians of intermarriages of plebeians into their families—was clearly settled, and regarded as a branch of the law respecting personal status. The struggles between the patricians and plebeians, during the infancy of the republic, had caused the legal doctrine of obligations to be laid down with the utmost precision.

These three great heads included the whole code of the distributive law. There was, however, no systematic legislation at Rome. The lawyer was left to supply *hiatus* in the written law by analogy and by quoting previous decisions. On rare occasions special supplemental legislation was resorted to. A law, properly so called, was a decree of the senate sanctioned in a *comitium*. When the patrician power predominated, the force of law resided in a mere resolution of the senate. When the popular party held sway, the force of law was a decree of the popular assembly; and this, like the other, retained validity by prescription. Thus Roman distributive law, although systematic and coherent in itself, existed nowhere, as a whole, except in the minds of the lawyers. It was a sealed book to the mass, and individual judges could wrest it with impunity in individual cases.

The penal law was worse. The Roman citizen could be proceeded against only in flagrant cases, and was then liable to very inadequate punishment. Non-citizens were very much at the mercy of an arbitrary judge. Slaves, again, were not recognized as *persons;* they were mere vessels of clay, to be broken or preserved according to the whim of their owners. The provisions of the Roman penal law were few, generally enacted in moments of political excitement, and with reference to a special case.

The great defects of the Roman law were (1) its indefinite character, from its being unwritten; (2) its being unknown to the great mass of the citizens; (3) the imperfect organization of the courts in which it was dispensed. There was a superabundance of courts, but their jurisdiction was very imperfectly defined. There was, besides, no subordination of courts to facilitate redress by appeal. The governor was military commander, head of the executive of the province, and judge. Imperfect management and inevitable injustice were the consequences. Wealth and influence usurped the functions of law, and at their hands the poor man had no redress. The rich man, when sued by a less wealthy opponent, had only to appeal from the inferior to the governor's court, and thence to Rome. Thus he could protract the suit indefinitely. Roman law was known only to those who had wealth, leisure, and talent. Whoever wished to obtain justice required to put himself under the protection of one of this class, and become his *client.* These unfortunates were forced to buy their services by becoming courtiers, dependants, political retainers, and partisans. The study of law thus became the surest way to political eminence. The eminent lawyer availed himself of his legal skill in two ways, (1) to acquire the admiration and confidence of the multitude, and (2) to attach to his interests a band of agents ready to promote his ambitious ends.

The distributive law of Rome still survives as a noble monument of genius; but it was a goddess imprisoned, and in whose name the utmost iniquities were perpetrated. *Law* was a spell-word, used solely for selfish purposes and individual aggrandizement. The executive organization of the state was still more defective. The provinces were farmed out, and the management of the national finances was oppressive, unproductive to the treasury, and destructive of public morals. In the provinces alone taxes were paid. The tax-

gatherers were appointed at Rome, and there only complaints could be brought against them. It was the interest of the Roman citizen that the highest rent should be obtained from the tax-farmer, and it was his interest to extort as much as possible from the tax-paying population. The wealthiest competitor was most likely of success; he had the means of making himself popular among the electors, and once popular with them, he was certain of the patronage of ambitious intriguers for the higher offices of the state.

That branch of the executive intended to enforce judicial decrees, prevent crime, and repress popular outbreaks, was extremely ill provided for. In peaceful times public opinion deterred men from refusing to obey citations; but under popular excitement the dictates of the magistrate were little respected. Beyond the limits of Italy standing armies supplied the place of a police; but only on extraordinary occasions, when the dignity of the Roman state was cencerned, were they called in. Their functions, and the forms according to which they were to discharge their duties, were not prescribed by definite constitutional law. Their authority being thus unsettled, they were necessarily feeble in the daily duties of police, and arbitrary and unrestrained when circumstances armed them with temporary power.

Of all the Roman institutions, the army alone was well and adequately organized. Circumstances had made the Romans a nation of warriors, and with their resources their skill increased also. After the Trans-Italian provinces became permanent dependencies of the state, standing armies were indispensable. To keep their new subjects obedient, armies were permanently stationed among them. Those armies were schools of military science. It was for the interest of all Romans that the best generals should be appointed; and their officers had a sufficient motive to exertion in the knowledge that their command would remain in their hands no longer than they continued successful. The constitution of these armies was, however, essentially different from that of the army of early Rome. The citizens had relinquished service in the ranks to needy adventurers. The camp became their home, and the standard the object of the practical worship of the legionary soldier. The auxiliary complements, composed of non-citizens, felt that while they continued soldiers they possessed privileges and an importance which did not belong to them in private life. The commander was supreme judge, and head of the executive of his province. He exercised within it a power to which the precariously exercised supremacy of Rome opposed few checks. So long as he possessed the affection of the soldiery he had little to fear; he could impose his own terms upon the faction in the ascendant at home.

In Italy the predominating tone of society was rustic. In Gaul and Spain it was that of barbarians aping the superior refinement of their conquerors. In Greece it was polished. In Numidia it was barbaric, with an occasional partial gleam of the civilization introduced by the Carthaginians. In Asia and Egypt it was voluptuousness tempered at times by Grecian refinement.

In the popular creed of Rome at this period we meet with little change. An immense number of new gods had, indeed, been grafted upon the old mythology. But these deities did not gain admission to the pantheon through the mere whim of the Roman populace; their reception was dictated by a sound policy, to which the Roman arms owed much of their success. This policy developed itself at the commencement of their career; for they soon learned that spiritual arms were as effective as physical force in subduing the hostile tribes which surrounded them. When they laid siege to a city they, to win them to their favour, promised its tutelar deities finer temples and richer sacrifices in Rome, should they desert their old worshippers. The people, feeling themselves deserted by their gods, yielded more readily to the Roman arms. The new deities were accordingly installed at Rome. The tutelar deity of Rome was a being without a name; it was unknown whether it were a god or a goddess. The rites of public worship were performed by the pontiffs and augurs. At first both offices belonged to the patricians; but the plebeians had acquired a right (1) to vote in their election, and (2) to appoint one of their own number to the augur's college. The mysteries, however, were looked upon by the wealthy and powerful simply as a convenient means of restraining the ignorant and superstitious. The distinction between patricians and plebeians had become nearly obsolete. One by one the offices of the state and of religion had become accessible to plebeians. But the way to obtain them was as narrow as before—it was no longer birth, it was wealth, that marked out the parties eligible to office. The names of patrician and plebeian, however, became the watchwords of political factions which contended for the possession of offices and dignities to be made use of merely for their own aggrandizement.

The rural districts of Italy had been drained by the wars of the republic of the best portion of their free population, and the patricians had possessed themselves of the greater portion of the soil, which they cultivated by slaves. The tax-gatherers emulated the patricians. In this way the country may be said to have had a population of lords and slaves, but a free labouring population was nowhere to be found. To this period we refer the depopulation of Italy, so often attributed to the devastations of the northern tribes at a later period. The villa of a wealthy Roman citizen usually occupied the site of a city which had its name in the annals of ancient Rome. The territory for miles around was cultivated by his slaves. The free population that remained was poor and ignorant; despised by the wealthy, it learned to despise itself, and associating only with slaves it gradually sank to their level and blended with them.

In the dependent Trans-Italian states the name of citizen had no real power, but it promoted the interests of such as chose to become the parasites of a governor. It was a title of rank constituting the bearers the minor nobility of a minor court. The free class of non-citizens, if they were poor, were little superior to slaves; if rich, they had no career of ambition open to them. Their only occupation was intrigue and feuds among themselves.

It might seem, at first sight, that in the condition of slaves there could scarcely be sufficient variety to render detail necessary. The epithet *slave*, however, attached to widely different conditions. The wars by which the Roman power had grown so gigantic had caused the slave population to outnumber the free. In some Eastern regions power was in the hands of the slaves. In many of the nomadic tribes of Arabia, and some of the less advanced Celtic and even Libyan tribes, the difference between bondsmen and freemen was little felt and easily effaced. In Central Rome and the adjoining provinces the chain of slavery weighed heavily. Yet even there there were exceptions. By the chances of war many highly educated individuals, brought to Rome as slaves, acquired sufficient influence by their talents greatly to alleviate their lot, even when they did not obtain enfranchisement. The earliest *literati* of Rome, and the pedagogues by whom the children of wealthy Romans were instructed, were slaves. The confidential secretary and the master of the household were usually of this class. But the domestic drudges, and those of lower qualifications, drank the draught of bondage in all its bitterness. Many wealthy Romans kept troops of gladiators, composed of slaves whose business it was to butcher one another for the amusement of their lordly masters.

We mentioned the Illyrians as a piratical nation, but piracy was not confined to them. Every maritime state, dismembered and erected into a Roman province, sent forth its bands of pirates, and every inland state similarly circumstanced produced bands of robbers. These were, at first, hardy soldiers who disdained to wear a foreign yoke, but were speedily augmented in numbers by desperadoes whose business it was to prey upon all parties. Runaway slaves, fugitives from justice, deserters, and disbanded soldiers swelled their ranks, and gave them importance. The swarms of pirates on the coast of Illyria and Epirus, around Crete, in the harbours of Thrace, Asia Minor, and the Euxine, gave the Romans much trouble for more than a century.

Having passed in review the various classes which constituted society, we are enabled now to reconcile the seeming inconsistency and incoherency of Roman history. We see how the state which was sufficiently powerful to crush

monarchs. was incompetent to extirpate bands of robbers; how the armies of the city which vanquished the colossal power of Carthage, set in motion by the genius of Hannibal, trembled and four times quailed and fled before the Thracian Spartacus at the head of a band of gladiator and fugitive slaves (73–71 B.C.) Above all, we can now understand how the scrupulous Cicero and the unscrupulous Catiline could be citizens of the same city at the same time. We see the genius of the one developing itself in the schools of Greece, and eliciting the applause of the better spirits of his age. We see the other—amid the license of the camp, exposed to the contaminations of associates who had grafted upon the rusticity of the Roman character the sensual voluptuousness of the Asiatic Greek and the reckless avarice of the soldier's life—grow up a prodigy of sensuality, avarice, and tyranny.

The unsettled institutions and imperfect organization of the state allowed free scope to the wildest passions. Men who had emancipated themselves from belief of a moral element in the popular creed, substituted priestcraft for religion. The precepts of household morality were thrown aside before men had attained to more comprehensive ethics. Wars without, and civil broils within, generated a spirit which became coarse as it waxed strong. The management of the public business in all that regarded personal security was ostentatious, but a chaos. The triumphal procession was succeeded by the flow of civil blood in the forum, and the stately pageant of the procession of priests to sacrifice to the gods was followed by the barbarous spectacle of gladiatorial fights. One moment we admire the code of distributive law as an invaluable legacy to the civilian, and listen with delight to the philosophic discourse of Atticus and Cicero; but the next our attention is drawn to Catiline amid his conspirators quaffing their dreadful sacrament of blood.

The influential events which characterize this period follow each other in rapid succession. The forms of the constitution are preserved only to be perverted to serve the purposes of the powerful. Marius was its virtual sovereign at the beginning of this era; Sylla succeeded Marius, and Pompey Sylla. But Marius, Sylla, and Pompey all exercised their power ostensibly according to the forms of the commonwealth. Others attempted to grasp at their power in defiance of these forms, and failed; the virtue of habit was still too strong in the mass to submit to open despotism. The incessant shifting of power from one blood-stained hand to another was, however, rapidly breaking down this last remnant of independence. The greatness of the Roman state had outgrown its intelligence; complex relations crowded themselves upon men faster than they could make legal provision for them; perplexing political problems sprang up demanding, like the riddle of the Sphinx, instant solution under penalty of death —the burden outgrew the strength of the bearer, and stirred him to a state of things that produced bewilderment rather than energy. Men became terrified and eager to purchase counsel from any quarter at any price. The tyrannies of Marius and Sylla had been comparatively innocuous. This was remembered amid the aimless broils of the republic, and disposed men rather to hazard political slavery than submit to the rank anarchy which disorganized Rome. Cæsar stepped in at this moment. His was the genius to restore order. The fulness of time was come, and Cæsar's was the genius created for the occasion.

Cæsar's assumption of power has been called usurpation. Cæsar, however, took the reins of government with the approbation of an overwhelming majority of the people he was to govern. That his government had the concurrence of the people is proved by this single fact, namely, that it required a conspiracy and an assassination to remove him from his seat: an appeal to the public was felt to be out of the question. Even after he was removed, the knot unloosened by the assassins was immediately reknit by his very inferior successor Octavius. In his elevation to the supreme power the crumbling constitution of republican Rome perished.

Having brought our history down to that point at which the nominal republic is rapidly merging into an empire, we shall, in the next chapter, give some account of the Assyrian and Persian dynasties up to their absorption within the imperial dominions of all-conquering Rome.

CHAPTER VI.

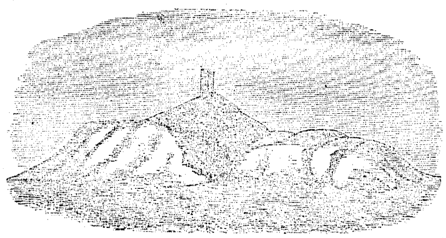
NINEVEH—BABYLON—THE MEDES AND THE PERSIANS.

Cæsar's usurpation of sovereign power, and the successful efforts of his successors to retain that power, brought Rome more on a level with the provinces. Roman citizens, no longer the masters of these districts, were only fellow-subjects of the provincials. The governors appointed by the emperor or the senate familiarized the provincials with Roman polity; and the Romans who accompanied them, ingrafting the habits of those among whom they lived upon their original stock, returned to Rome to make their fellow-citizens like themselves. The old Roman character was modified under imperial sway by the character of the people with whom the Romans were brought into contact. We restrict our attention now to those countries in which the population was not of Greek origin. The Greek race, up to the moment of the Roman conquest, held "sovereign sway and masterdom." An immense space—embracing Greece Proper, Thrace, the coasts of the Black Sea, Asia Minor, Asia bounded by Mount Taurus, the Oxus, the Indus, the Indian Ocean, the Arabian Gulf, and the eastern extremity of the Mediterranean, Egypt, and Cyrene in Africa—was inhabited by Greeks or by people governed by Greeks, or had governments organized by Greeks. Greek civilization, literature, arts, arms, and civil polity were felt throughout this whole extent. In these provinces Greek civilization had been ingrafted upon an older civilization. The sceptre was transmitted to the Greeks from the Persians.

There appear to have been two great states which grew up to maturity about the same time in the countries adjoining the Euphrates and Tigris—the Assyrians, whose capital was Nineveh, and the Babylonians. The intervening space was commonly called Mesopotamia ("between rivers"), and in Scripture this whole district is spoken of as "the land of Shinar." It is certain that the Babylonians were so called from Babylon, their metropolis. As that city was occasionally designated the head of the Chaldeans, it is possible that the majority of its citizens and subjects may have been of that fierce warrior race which dwelt at one time between the mountains of Armenia and the embouchure of the united Tigris and Euphrates, though spreading occasionally its devastating hordes over Syria, Palestine, and Phœnicia, the broken memorials of which are still to be found in scattered villages between the ruins of Nineveh and the Armenian mountains. Two circumstances lead us to infer that the Assyrians were a different race. It appears from the Hebrew annals that the Assyrian monarch conquered Babylon a short time before the captivity of Israel. In the Hebrew books mention is made of Chaldeans as a peculiar body of diviners at his court. Herodotus, at a much more recent period, gives the designation *Chaldeans* to the attendants in the temple of Belus or Baal at Babylon. This notice of the Chaldeans as a people apart, and their connection with the Babylonian worship, leads us to infer that the Assyrians were a separate race from the Chaldeans—an idea strengthened by a passage in the Second Book of Kings, from which we learn that the national god of the Assyrians was called Nisroch. It is possible, however, that Babylonians and Assyrians may have been two sections of the same race. The leaders of the Jews, when they wished to conceal the threatening message of Salmanasar the Assyrian king from their followers, requested his messenger Rabshakeh to use the dialect of Aram and the Babylonians: the Chaldean tongue was an Aramitic dialect of the Semitic speech. As Babylonian from Babylon, so Assyrian may have been derived from Assur, and may have merely designated those Chaldean tribes inhabiting Assur and subject to its sovereign. All that we can say with certainty is, that some time before the overthrow of Jerusalem by the generals of Nebuchadnezzar, the plains and hills between the Tigris and the Euphrates, and the southern and western slope of the mountains eastward of the former river, were the scene of the struggles for ascendency between

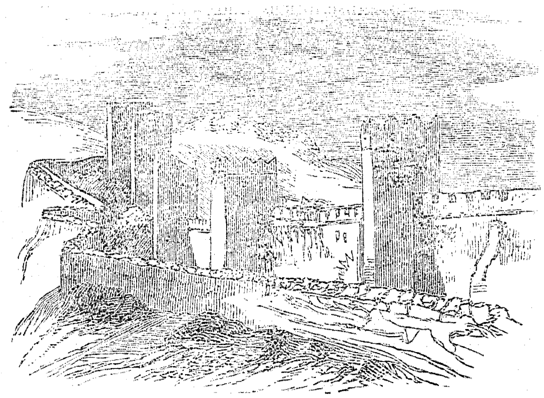
the Assyrian and Babylonian powers, which terminated in the subjection of the latter. Nineveh was the capital of the one, Babylon of the other power.

Babylon was built before Nineveh. The historian Josephus ascribes the erection of the Tower of Babel to Nimrod, and this tower was the commencement of the future city.



Sirs Nimroud, the supposed Tower of Babel (conjecturally restored).

The palace of Nimrod was the first edifice, with a royal park and a cluster of hamlets around it. He ascribes to Nimrod, also, the founding of Nineveh; but on this point the evidence of history is uncertain. Ninus, a descendant of Nimrod, married the famous Semiramis, who first set the Assyrian Empire in a great and solid foundation, and Nineveh was probably at this time the capital of that empire. Semiramis, however, enlarged and adorned Babylon, until it became a truly magnificent city. She is said to have collected, from all the provinces of her vast empire, 2,000,000 men, whom she employed in this gigantic undertaking. The city was erected in the middle of the extensive plain of Shinar, and occupied both sides of the Euphrates. Its walls, according to Herodotus, were 87 feet in thickness. 350 feet in height,



Supposed Walls of Babylon (from an ancient coin).

and 480 furlongs or 60 miles in circuit. These walls were built of brick, cemented with bitumen, and encompassed the city in the form of a square, each side of which was 15 miles in length. The river ran through the city from north to south, and on each side was a quay of the same thickness as the city walls. In these there were 100 gates of solid brass, twenty-five in each side of the square, and from all the gates proceeded streets in straight lines, each being 15 miles in length, and crossing each other at right angles. On the eastern side of the river stood the ancient palace, which was 3¾ miles in the circuit of its walls; and on the opposite or western side of the river was another palace, the walls of which, with its inclosed grounds, were 7½ miles in circuit. In the middle of the city Semiramis erected a lofty temple, in honour of Belus. It stood near the ancient palace; and, rising from this temple, was a tower of gigantic magnitude, celebrated in ancient history. The Hanging Gardens, so often mentioned with admiration by the Greeks, were at a subsequent period attached to the western palace.

Nineveh was not less imposing in its proportions and in the magnificence of its buildings. According to Diodorus Siculus, this was the largest city in the world. It was built in the form of a parallelogram, its longer sides being 36 miles in length and its shorter about 24. The walls were 100 feet high, and so broad as to admit of three chariots being driven abreast. They were fortified with 1500 towers, each 200 feet high. The city, though so vast, contained little more than 500,000 inhabitants; the houses were far apart, and within the civic territory there were gardens, parks, vineyards, orchards, corn-fields, and royal demesnes. It is estimated that the area of Nineveh was 216 square miles. The majority of the houses, however, contained only one storey, so that the people were spread over a wide area.

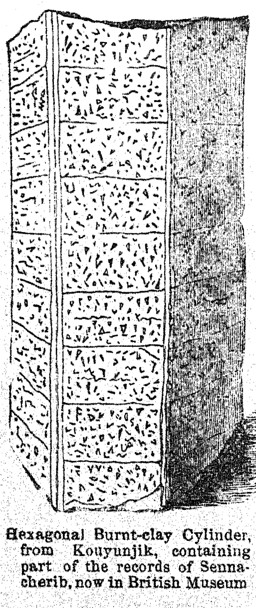
These two cities, Nineveh and Babylon, continued, under one imperial government, to constitute the twin-capitals of Assyria for several centuries. Semiramis, after enlarging the latter, thirsted for conquest. Assembling a numerous army, she marched through Media into Persia, then into Egypt and Ethiopia; and finally, after a career of great glory, carried her arms against the Indian nations, by whom she was signally defeated, and soon afterwards died. Her son, Ninyas, succeeded, but little is known of his reign. For 1200 years the history of Assyria is almost an utter blank. The last of the monarchs in the series of about thirty reigns was Sardanapalus, celebrated only for his indolence, effeminacy, and voluptuous luxury. In his reign occurred the revolt of the Medes, which resulted in the fall of the first empire. Of this event we have two accounts by Greek authors—Ctesias and Herodotus—differing considerably from each other. The revolt was made, says the former historian, by Arbaces, "a valiant and prudent man," "and general of the forces who were sent every year out of Media to Nineveh." He had been stirred up by Belesis, the governor of Babylon. Arbaces prevailed on the Medes and Persians to invade Assyria, and Belesis persuaded the Babylonians to aim at their independence by joining in the enterprise. Sardanapalus at first displayed considerable energy. He led forth the forces of the other provinces against the rebels, and twice defeated them in battle with great slaughter. This success led to security. While he was rejoicing in his victories, and feasting his army, Arbaces induced the Bactrians to revolt, suddenly attacked the royal camp, in which he made a great slaughter of some, and forced the rest into the city. Sardanapalus committed the charge of the army to Salamenes, the queen's brother, and took upon himself the defence of his capital. But the tide of battle was turned against him. His forces were twice defeated by the rebels, and this encouraged the revolt of other provinces. The city, however, was strongly fortified, and the king, having made extensive preparations for a siege, continued to hold out, encouraged by an ancient prophecy, "that Nineveh could never be taken by force until the river became the city's enemy." For two years the siege continued; but in the third year, the Tigris, swollen by incessant rains, overflowed its banks, inundated part of the city, and swept away 20 furlongs of the lofty and massive wall, which had hitherto resisted all the attacks of the besiegers. The king, conceiving that, the oracle being thus accomplished, the doom of Nineveh was sealed, sullenly resigned himself to fate. But that he might not fall into the hands of the enemy, he caused an enormous pile of wood to be erected in his palace court, on which he heaped together all his treasures—his gold, silver, and royal apparel. Then, inclosing his eunuchs and concubines in an apartment within the pile, ordered it to be set on fire, and he, with all the objects of his guilty and sensual attachment, perished in the flames. The revolters entered through the breach which the river had made, took the city, and proclaimed Arbaces king.

This was the end of the first great Assyrian Empire, and of the pride of Nineveh as its capital. Out of the ruins of this empire sprang three kingdoms—Media, Babylon, and Nineveh. Belesis reigned in Babylon, Arbaces in Nineveh; and during the existence of the dynasties founded by these usurpers, the two kingdoms were engaged in frequent rivalry. Belesis, who reigned in Babylon B.C. 747, is the same with Nabonassar, and was succeeded by his son, Merodach-baladan. Sennacherib, one of the descendants of Arbaces, came to the throne of Nineveh B.C. 717, and extended his conquests westward to Palestine. His son, Esarhaddon, added Babylon

to his father's conquests, and thus the two great cities were again united under the same sceptre. Esarhaddon, after a notable reign of thirty-nine years, was succeeded by his son, Saorsduchirus; after this prince reigned Chyniladan, and he was succeeded by Saracus, B.C. 648. Under Saracus Nineveh was taken and utterly destroyed by Cyaxares, king of the Medes, assisted by Labynitus, king of Babylon, who is presumed to have been the same as Nabopalassar.

Thus perished the great city Nineveh, upwards of six centuries B.C., after having flourished as the capital of the Assyrian Empire, and the residence of mighty kings, for nearly 2000 years. Babylon now became the capital of the second Assyrian Empire. With Nebuchadnezzar, who succeeded his father Nabopalassar, commences the era of Babylonian greatness. Babylon became the mistress of the East, and Nineveh a mass of ruins. The celebrated Hanging Gardens, familiar to every reader of history, and other stupendous creations of wealth and labour, were added to Babylon in this reign by Nebuchadnezzar or his queen Nitocris. The Chaldeo-Babylonian Empire, which comprehended all Western Asia, was in the zenith of its glory. On Nebuchadnezzar's death it began to decline, and under his third or fourth successor it fell into the hands of Cyrus the Mede. "He came at last," says Xenophon, "to Babylon, bringing with him a mighty multitude of horse, a mighty multitude of arms and javelin men, but slingers innumerable." He made preparations to blockade the city, but people laughed at the apparent folly of the undertaking. Babylon contained within its walls, not only gardens and large open spaces for purposes of pleasure, but a sufficient quantity of land for tillage to support the inhabitants during a siege. They knew that they had command of provisions for twenty years at least. Cyrus had no intention of prolonging the siege. The river Euphrates flowed through the middle of the city, and the crafty Mede "dug round the wall on every side," as Xenophon says, "a very great ditch, and they threw up the earth towards themselves. In the first place, he built turrets on the river, laying their foundations on palm-trees, that were not less than 100 feet in length—and palm-trees that are pressed bend up under their weight, as asses do that are used to the pack-saddle. He placed the turrets on these for this reason, that it might carry the stronger appearance of his preparing to block up the city." The people laughed louder than ever at these preparations, and indulged in a reckless security, inspired by fatal confidence. The ditches were finished, and one night when the Babylonians had a great festival, Cyrus opened the sluices of the river into these vast reservoirs; the river deserted its ancient channel, that now became passable for an army, and Cyrus marched into the city and took possession. Babylon was taken, and the second Assyrian Empire ended, B.C. 538.

Ruins of Babylon.

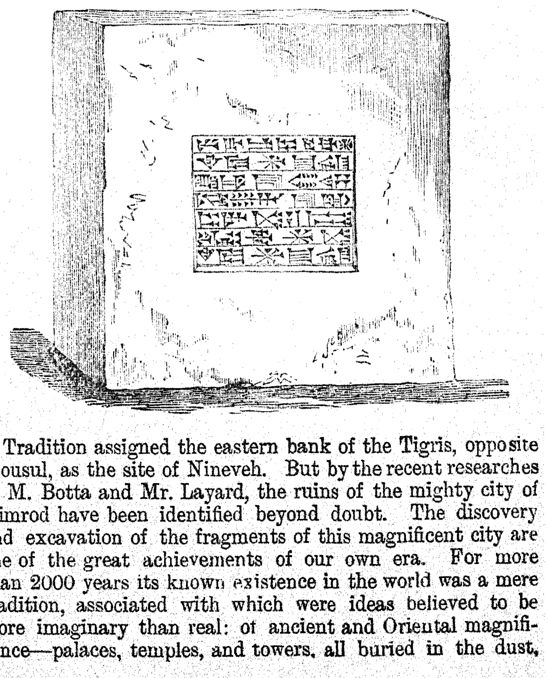


Hexagonal Burnt-clay Cylinder, from Kouyunjik, containing part of the records of Sennacherib, now in British Museum

The city was shorn of its glory, and its imperial honours destroyed. For two centuries it remained subject to the Persian power. Then it fell under the resistless arms of Alexander the Great. Here it was that the mighty conqueror died. Seleucus, one of his captains, received Babylon as his province; and, for a time, the Seleucidæ made it the seat of empire. Babylon soon succumbed to Rome. It dwindled away, and ultimately sank into desolation and ruin.

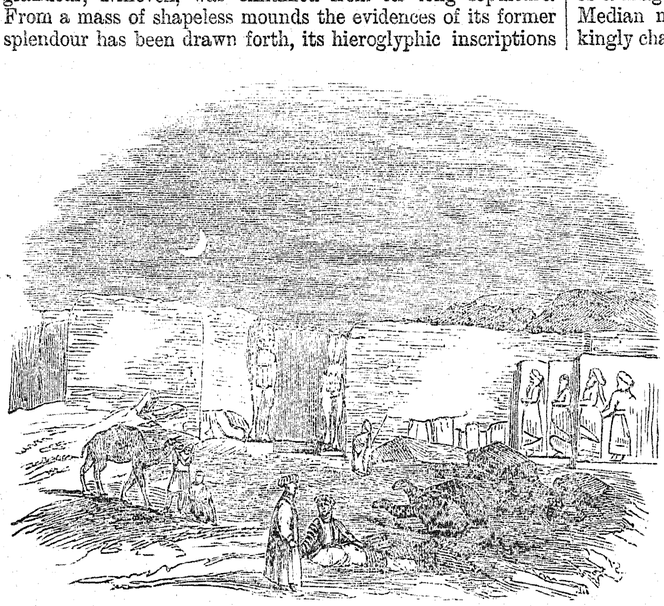
This immense city was long reduced to a few unsightly mounds, and has actually been buried in the soil for upwards of 2000 years. A succession of writers have given a description of the mounds of earth and fragments of massive walls, half buried in soil and sand, which constitute the remains of the once magnificent Babylon. No very beautiful works of art have been found in these ruins; but bricks and gems, with inscriptions and sculptures, demonstrate the early connection which subsisted between the Babylonian and Persian empires. The inscription upon the following specimen from Babylonia, now preserved in the collection of the Royal Society of Literature, is read by Sir H. Rawlinson as follows :—

(of) NEBUCHADNEZZAR,
the king of Babylon,
founder of Beth Digla, or Saggalu,
and of Beth Tzida,
son of NABOPALASSAR (I am).



Tradition assigned the eastern bank of the Tigris, opposite Mousul, as the site of Nineveh. But by the recent researches of M. Botta and Mr. Layard, the ruins of the mighty city of Nimrod have been identified beyond doubt. The discovery and excavation of the fragments of this magnificent city are one of the great achievements of our own era. For more than 2000 years its known existence in the world was a mere tradition, associated with which were ideas believed to be more imaginary than real: of ancient and Oriental magnificence—palaces, temples, and towers, all buried in the dust,

and supposed to have left no traces except the exaggerations of history. Suddenly this monument of ancient power and grandeur, Nineveh, was exhumed from its long sepulture. From a mass of shapeless mounds the evidences of its former splendour has been drawn forth, its hieroglyphic inscriptions



Palace of Nimrod.

have been deciphered, its palaces have been ransacked for records, and history and tradition have been confirmed.

A range of mountains runs across Asia from the south-western angle of Asia Minor to the Caspian Sea, the chain of Mount Taurus. From the eastern extremity of this chain several spurs stretch downward to the shores of the Persian Gulf. The western slopes of these mountains, towards the Tigris, were inhabited by the subjects of Babylon and Nineveh. The eastern side, to the north, was the land of the Medes; the southern extremity of the range, that of the Persians. According to Herodotus, there were six tribes or clans of the Medes and nine of Persians. Five generations before Cyrus—a name familiar to all readers of biblical history—the Median tribes had been brought into subjection by Deioces. His descendants had engaged in frequent wars with their neighbours, the Assyrians of Nineveh. The Persian clans continued to be united among themselves till the time of Cyrus. He instigated his kindred clans to attack their neighbours; and, having made his kinsmen masters of the Medes, persuaded them in turn to allow him to be their master. The old hostilities between the Medes and the Mesopotamian tribes involved Cyrus in a war with the latter. Nineveh seems to have been taken by the last Median monarch a short time before the overthrow of his throne by Cyrus. Babylon was taken by Cyrus himself; and, by the conquest of these two mighty cities, the Assyro-Babylonian tribes were subjected to the Medo-Persian. Conquest infallibly leads to conquest, and war to war. Crœsus of Lydia, the seat of whose empire was in Sardis, had, about the time that Cyrus finally humbled the Assyrian power, subdued all the Asian tribes north of the Taurus and south of the river Halys. The two conquerors came into collision, and Crœsus succumbed. Cyrus, not long after, fell leading his troops against the Scythians on the north-eastern frontier of his empire. His son, Cambyses, overran the parts of Syria and Palestine not previously subjected by the Assyro-Babylonian monarchs, and the greater part of Egypt. These conquests were confirmed by his successors on the Medo-Persian throne. The limits of the Medo-Persian monarchy, therefore, at the time it was brought into collision with the Greeks by encroachments on their colonies, extended along the coast from the innermost recesses of the Black Sea to the shores of Syria.

Over this wide expanse the whole power was wielded by the Median and Persian clans. According to the Greek authors, the father of Cyrus was married to a Median princess. After the death of Cambyses, the short usurpation of a Magian priest was followed by the election of Darius, a Median nobleman, to the throne, in whose descendants the kingly character remained till the subversion of the monarchy. The conquered Chaldeans—and, still more, their subjects—seem never to have been admitted to an equality in civil matters with the mountain warriors. The intra-Halytic tribes, too, the tribes of Palestine, appear to have been held in a position of dependence.

On the organization of the supreme power, after the final establishment of the monarchy under Darius Hystaspes—excellent for the purposes of the monarch and of those who governed in his name—the state was divided into satrapies. In each a satrap wielded the civil and military power. His business was to preserve peace within his province, to uplift and transmit to the capital the royal revenues, and to bring into the field, at a moment's warning, the whole military force of the province, or as much of it as might be called for by the king. Throughout the empire the distance between the most important cities was accurately measured; resting stations were erected at convenient distances; and establishments for expediting royal messengers, and the conveyance of goods and travellers connected with the court, were kept in constant efficiency. The only check upon the monarch's will was the necessity of keeping in good humour his powerful nobles, the chiefs of the Median and Persian clans. The power of the nobles who obtained these rich satrapies would have been supreme, but for the necessity of paying to the king a portion of the tribute they exacted from the people, and of following him in his wars. If a satrap withheld the tribute, or disobeyed the royal mandate to call out and march his troops; if he goaded the people to rebellion and was not sufficiently energetic to crush that rebellion, he might be looked upon as a bad governor, and displaced. In no other way could he incur the royal displeasure, except, indeed, from the whispered misrepresentations of courtiers. There was no security for the people in such a government. The Persian monarch was a general, and encamped his forces so as to secure all the wealth of the country they occupied. He had the power of making all male inhabitants capable of bearing arms serve as auxiliaries in his wars. The organization of the public establishments had these ends in view, and these only.

Of the domestic manners, of the languages, laws, and religions of the tribes held in subjection by this skilful organization, our knowledge is scanty and confused. In describing the civil organization and religious hierarchy of special towns and districts, the historians never distinguish what was native and indigenous from what had been introduced by the ruling powers, or by the amalgamation of different tribes.

Out of the historic chaos and confusion we may gather this. The Persian monarchy was built up of the fragments of the Babylonian, Assyrian, Egyptian, and Lydian realms. The Lydian had been formed out of the fragments of many earlier and smaller states in Asia Minor. The Assyrian had risen on the ruins of the Babylonian, Syrian, Hebrew, and Phœnician nations. Their territories had been first wasted and then peopled by conquered hordes removed thither from a distance. The conquered had been forced to bow the knee to the gods of their conquerors. The conquerors, at the instigation of superstition or policy, had knelt in turn to the gods of the conquered. The Belus of Chaldea is the Baal of Scripture, the early object of adoration of the Aramaic tribes. Hercules, so called by the Greeks of Tyre and Carthage, is possibly the same divinity. In the Venus Urania of Cyprus and the nearest shores of Syria, we have the Ashtaroth, Queen of Heaven, of the Sidonians. Mithra was the Persian object of adoration; whether an incorporated divinity of the imagination or the sun, it is hard to say. The name Magi is common to a body of priests and to a Median tribe

Chaldean is in like manner a name common to the priests of Bel and Babylon and to a warlike nation.

At the time the East was aggregated into a single despotism, in which the stores and treasures of antiquity were amassed in strongholds, the West, exulting in its rising strength, was seized with the greed of imperialism; and Rome, prepared by long and varied experience in warfare, resolved to heighten and consolidate its power by the humiliation of the ancient empires on which the suns of centuries had shone. Rome succeeded, and dominion passed from the East to the West.

GEOGRAPHY.—CHAPTER V.

PHYSICAL FEATURES OF EUROPE—THE GREAT PLAIN—MOUNTAIN SYSTEMS—BOUNDARIES—POLITICAL DIVISIONS—NATURAL PRODUCTIONS, &c.

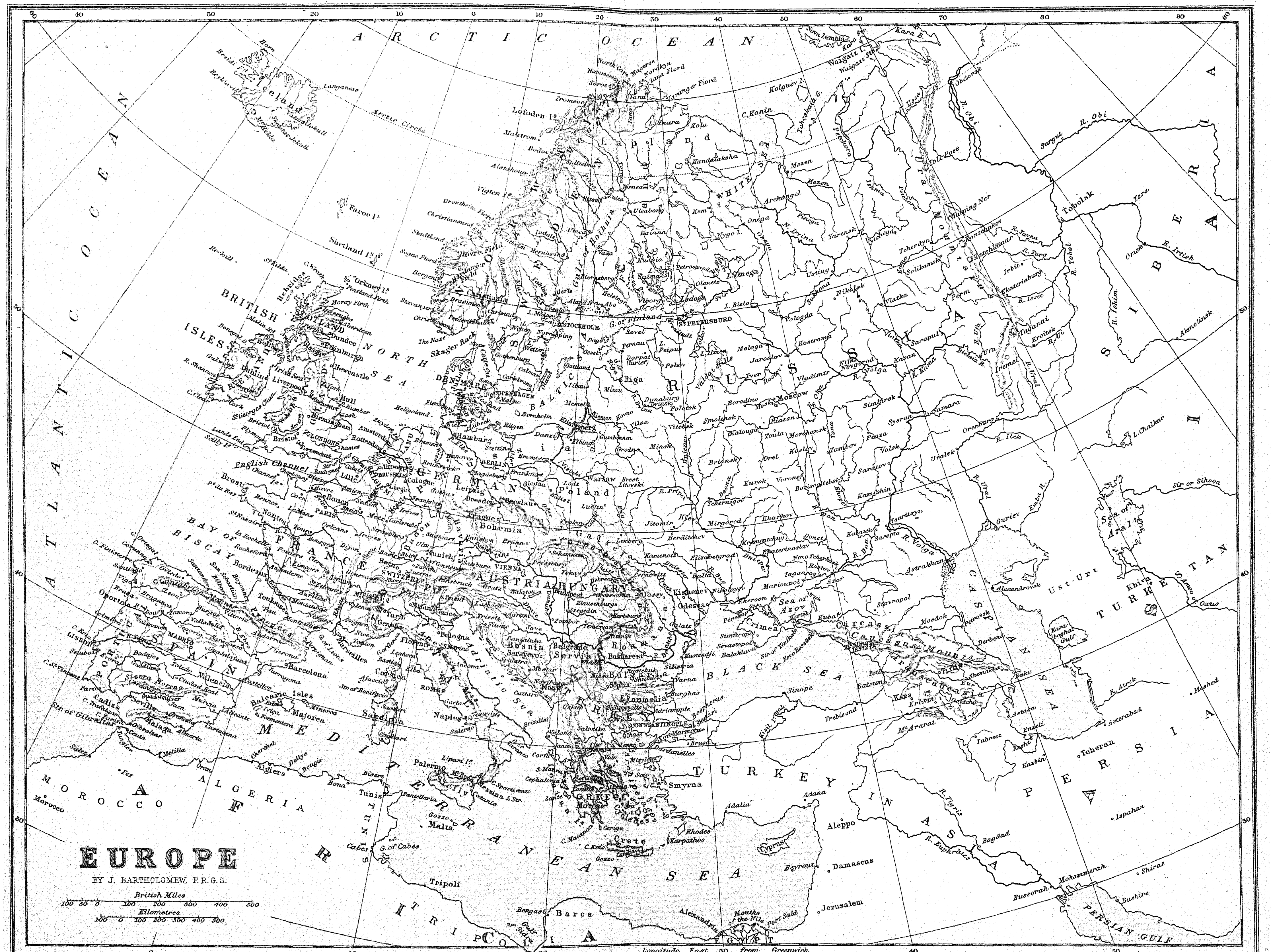
THE name Europe makes its first appearance as a geographical designation, twice repeated in precisely the same terms, in an old Greek "Hymn to Apollo," attributed to Homer. Herodotus mentions it several times. In "Melpomene" (45) he says, "It is not clear whence it received this name, nor who gave it, unless we will say that the region received the name from the Tyrian Europa, . . . yet she evidently belonged to Asia, and never came into that country which is now called Europe by the Greeks;" and in "Polyhymnia" (5) he represents Mardonius, son of Gobrias, cousin to Xerxes, as saying that "Europe was a very beautiful country, and produced all kinds of cultivated trees, and was very fertile, and was worthy to be possessed by the king (Xerxes) alone of all mortals." In the early dawn of existence the lofty forms of mountains and the fluid sweeps of the broad inland seas hemmed men in, and kept them surrounded by impressions of wonder, magnificence, and distance. By and by, the ardent and the hardy ventured to pass these natural barriers, and enter upon new stretches of pasture and grain land. Though Agenor's daughter Europa was, according to mythological fable, first carried over sea from Phœnicia by Jupiter, in the assumed shape of a bull, to Crete, the largest island in the Mediterranean; and thus the queen of beauty in Canaan—the lowland of the Asiatic shore—gave her name to the slip of land seen seaward from the heights of Idæa; yet the land must have been peopled by many others who had more prosaic means of migration. The Greeks inhabited the south-eastern corner of Europe, and by them the knowledge of the geography of the Continent was not much investigated. Phœnician navigation was checked by its subjugation to Persia. Greece lost, with its freedom, the spirit of discovery, and the Romans were never much given to naval enterprise. The mountains which separate the southern sea-board from the great plain, through which the vagrant hordes of early times wandered without settled government, restrained for a while the extension of power into the regions of the north, and hence little was known of the land beyond the Alps till ambition and warfare—afterwards succeeded by the humaner influences of commerce—extended the boundaries of knowledge, not by voyages of discovery, but by direct experience.

The land-surface of the earth is the residence of man. Its parts are distinguished by differences of position, extent, and form. Position is either positive or relative; the former is determined by giving details of latitude and longitude; the latter by stating the sea or land boundaries. The greater part of our ideas concerning the surface of the land-masses of the earth is obtained from maps or globes. These, in general, confine themselves to the exhibition of the horizontal configuration of the surface, and give little information regarding its vertical form and contour. Configuration depends on the sea boundaries, but form above the sea-level is also a necessary element of geographical knowledge. The ocean is, as its name implies, the encompasser. Continents are those land-masses which the sea surrounds. Each continent has its own peculiarities of configuration and its special features of inequality of level. All the shores of Europe, for instance, are deeply indented by bays, gulfs, and inland seas. Hence its coast-line is more varied and greater in proportion to its area than that of any other continent. Taking its course from the Strait of Waygatz, in the Arctic Ocean, to the Strait of Kaffa, at the entrance to the Sea of Azof, it extends to almost 20,000 miles. The proportion of linear miles of coast-line to square miles of area is in Africa 530, in Asia 376, in America 360, and in Europe 164. Land-masses exhibit also a greatly diversified surface in regard to elevation above the sea-level and the vertical contour of their features. The earth's crust presents to us lofty ranges of saw-like summits, jagged edges rising into the clouds, elevated ridges, or isolated peaks. The mean height of all the elevated parts of the surface of the earth above the level of the sea, if estimated, as Humboldt suggested, at about 1000 feet, the proportionate height of the continents might be stated as—Europe 671 feet, Asia 1132, North America 748, South America 1151, and Africa somewhat more than Europe, but less than North America.

The continents of the Old World form a closely-compacted mass of land, grouped together as the Eastern Hemisphere. Of the three great mainlands of these physical regions which have been, from the most remote antiquity, the scenes of human history, Europe is the smallest. Asia contains nearly nine-seventeenths, Africa rather more than six-seventeenths, and Europe somewhat less than two-seventeenths of the surface of that old continental land-mass. Europe, however, within its space is more varied and more peculiarly organized than any other of the great divisions of the earth. It stretches between the thirty-sixth and the seventy-first degrees of north latitude, and between the tenth degree of west and the sixty-fourth degree of east longitude. Its greatest length, from its south-western to its north-eastern extremity, is 3490 miles; and its greatest breadth, from its south-eastern to its north-western extremity, is about 2400 miles. The superficial area is about 3,822,000 square miles, and its population over 350,000,000.

Considered in configuration, Europe is in fact a large peninsula cut up by sea-arms into several smaller peninsulas, so that the non-peninsular dry land is relatively very small when considered as a central body of connected and continuous extent. Her two great inland seas, her large interior plain, and her dorsal framework or backbone of mountains form the more prominent of the physical features she presents. The great plain we might represent to ourselves as a triangular area having as its base the eastern boundaries, its apex in Holland, one side bounded by the White Sea and the Baltic Sea, and the other by the Caucasus, the Black Sea, and the Carpathians. Between the outlets of the Elbe and the Scheldt the land scarcely rises more than 100 feet above the sea level, while some parts of the shore along the German Ocean are so low as to require to be dyked up to prevent the inroads of the waves. Lying between the Elbe and the Vistula, a water-shed of about 150 feet separates the small rivers which fall into the Baltic Sea from those which take their course along the interior of the plain. East of the upper reaches of the Vistula the rivers rise in the uplands of the plain they drain, and flowing north-west make their way to the Baltic, or north to the White Sea, or south and south-east to the Black Sea or the Caspian.

In the west this plain is covered with moor and heath. Extensive portions of fertile farmland and well-wooded breadths, with alluvial tracts, occur along the river-courses. The rivers which drain this part originate in the mountain regions to the south of it, and mostly traverse it in a northerly or north-westerly direction. Eastward the acclivities of the Carpathians form a fresh water-shed. Along the basin of the Priepec an immense swamp extends for a space almost as large as the surface of England. An undulating country, in which the Don and the Dnieper have their upper courses, passes upward to the Valdai Hills providing the sources of the Volga, and on its eastern slopes showing the immense forest land of Volkhousky. North of this water-shed the land is moderately fertile, and contains many large lakes. On the south of it the land is more fertile for a width of 300 or 400 miles. East of the Volga the country is hilly, traversed by offsets from the great ranges whose slopes are clad with forests, and by valleys of moderate fertility where there is any breadth to cross. Then there is the region of the steppes—the higher, in the western part of the plain, extending to the shore of the Black Sea; the lower, on both



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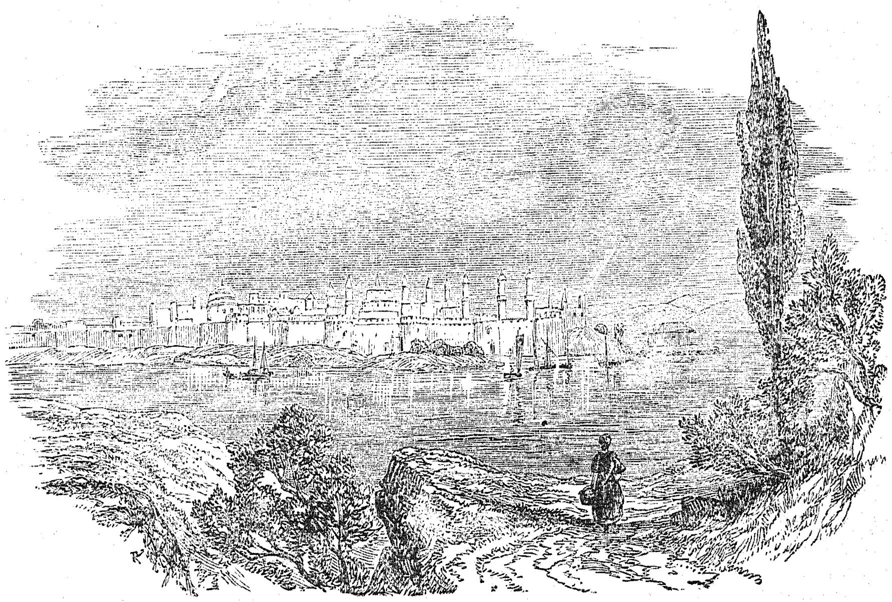
J. Bartholomew, Edinr

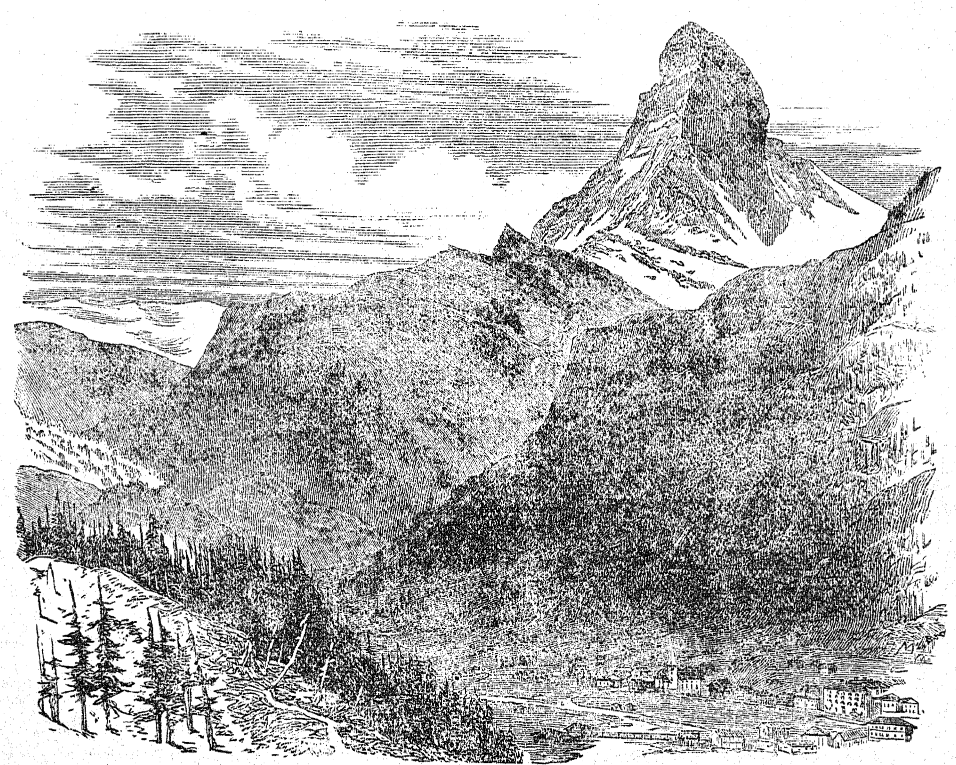
sides of the Volga and onwards to the banks of the Ural. Except near Astrakhan they exhibit few signs of agriculture. The whole plain occupies about two-thirds of the continent (2,500,000 square miles), and separates or lies embraced between the two mountain districts of Europe, one on the north, the other on the south.

The great mountain framework of Europe commences in the west with the outlying rock of Gibraltar (1457 feet),



Astrakhan.

which is separated but by a strait of 11 miles from Mount Accho, which indicates its relation to the Atlas range of Africa. In a series of seven ranges of sierras—presenting a saw-like sky-line of notch and peak—running through Spain and Portugal in a general direction from east to west, parallel with the shores of the Mediterranean, there is contained the



Matterhorn.

loftiest plateau on the continent. It rises to the height of 2000 to 3000 feet, and covers an extent of 90,000 square miles, one-half of the entire country. The summits of these ranges show heights unsurpassed by any European mountain-system except the Alps. The Pyrenees form a huge rampart lying between the two seas and dividing France from Spain by a narrow single ridge, whose crest is only broken by a few *ports* in the wall-like summit.

Principal European Rivers.—Of the running waters of Europe the different seas are calculated to receive the following proportions, supposing the whole to be equal to 100:—The White Sea and Arctic Ocean are estimated to receive 6 parts; the North Sea, 11; the Baltic, 13; the Atlantic, 13; the Mediterranean, 14; the Caspian, 16; and the Black Sea, 27. The elements of the more important rivers are given in the table:—

Rivers.	Length in Miles.	Area of Basin. Square Miles.	Embouchure.	Principal Places from Mouth to Sources on the Main Channels.
Dwina (Northern), . .	760	144,000	White Sea.	Archangel, Vologda.
Neva, ...	40	91,000	Baltic.	St. Petersburg.
Dwina (Southern), . .	550	45,000	"	Riga, Vitebsk.
Niemen (Memmel), .	400	43,000	"	Tilsit.
Vistula.	630	76,000	"	Dantzic, Thorn, Warsaw, Cracow.
Oder, ...	550	53,000	"	Stettin, Frankfort, Breslau.
Elbe, ...	690	57,000	North Sea.	Hamburg, Altona, Magdeburg, Meissen, Dresden.
Weser, ...	380	17,000	"	Bremen, Minden.
Rhine, ...	760	88,000	"	Leyden, Cologne, Bonn, Coblenz, Mayence, Strasburg, Basel.
Meuse.	550			Rotterdam, Maestricht, Liège, Namur.
Thames.	215	6,160	"	London, Windsor, Reading, Oxford.
Seine, ...	430	30,000	Atlantic.	Havre, Rouen, Paris.
Loire, ...	570	48,000	"	Nantes, Orléans, Nevers.
Garonne, ...	350	33,000	"	Bordeaux, Toulouse.
Douro, ...	460	39,000	"	Oporto, Zamora.
Tagus, ...	510	34,000	"	Lisbon, Abrantes, Talavera, Toledo.
Guadiana, ...	450	26,000	"	Badajoz, Merida.
Guadalquiver, . . .	290	20,000	"	San Lucar, Seville, Cordova, Villafranca.
Ebro, ...	420	34,000	Mediterranean.	Tortosa, Saragossa, Tudela.
Rhone, ...	490	38,000	"	Arles, Avignon, Lyon, Geneva.
Po, ...	450	40,000	"	Ferrara, Cremona, Piacenza, Turin.
Danube, ...	1630	310,000	Black Sea.	Silistria, Rustchuk, Widdin, Belgrade, Buda-Pesth, Pressburg, Vienna, Ratisbon.
Dniester, ...	700	31,000	"	Ovidiopol, Bender.
Dnieper, ...	1200	200,000	"	Kherson, Kiev.
Don, ...	1100	205,000	"	Azov, Tcherkask.
Volga, ...	2200	520,000	Caspian.	Astrakhan, Sarepta, Saratov, Kasan, Nijni-Novgorod, Tver.

Lakes of Europe.—The lakes of Europe are neither very numerous nor very important. There are numerous small sheets of fresh water which serve to vary, beautify, and enliven the scenery of the countries of which they form a part; but they are of little or no importance in a commercial point of view. Even the largest of them, when compared with the vast inland seas of North America, scarcely deserve the name of lakes:—

In Russia—Ladoga and Onega.
" Sweden—Wener and Wetter.
" Switzerland—Lake Geneva and Lake Lucerne.
Between Switzerland and Germany, Lake Constance.
In England—Derwentwater, Ullswater, Windermere.
" Scotland—Lochs Lomond, Awe, Tay, Leven, Ness.
" Ireland—Killarney, Neagh, Erne, Allen.
" Italy—Maggiore, Lugano, Como, Iseo.
" Greece—Topolias (Copais) in Bœotia.

THE FRENCH LANGUAGE.—CHAPTER VI.

II. DETERMINATIVE ADJECTIVES: DEMONSTRATIVE, POSSESSIVE, INDEFINITE, NUMERAL.

Adjectives in French show, as we have seen in Section I. (Qualificative Adjectives), a kindlier affection towards their nouns than English adjectives do. In their extreme complaisance, they assimilate both in number and gender to the noun whose qualities they denote, or whose place they for the time being supply. The French are peculiarly anxious to secure clearness of expression, and, that this end may be gained, they employ with special care all those words which help to discriminate between things, and to determine precisely not only what sort of things, but which particular individuals are referred to in speaking. Hence they have not only a greater number of determinative adjectives than we have, but they are much more careful in their use of them.

Determinative adjectives are used before nouns to point out with special distinctness the exact one to which reference is made. They are of four kinds: demonstrative, possessive, indefinite, and numeral.

(1) *Demonstrative adjectives* are those which particularly point out the thing of which we are speaking. These are *ce* or *cet*, singular masculine; *cette*, singular feminine; and *ces*, plural for either gender. *Ce* is used before a consonant or *h* aspirated; *cet* (in which *t* is purely euphonic) is used before a vowel or an *h* silent.

The following examples sufficiently show the use of this adjective:—

Mas.		*Fem.*	
ce soldat,	*that soldier.*	cette fille,	*that girl.*
cet enfant,	*that child.*	cette école,	*that school.*
cet homme,	*that man.*	cette herbe,	*that grass.*
ces garçons,	*those boys.*	ces dames,	*those ladies.*

The demonstrative adjectives are repeated before each noun which they serve to point out; as *Ce petit garçon, cet homme, cette femme, et ces enfants sont dignés de la pitié qu'ils vous ont inspirés*, This little boy, this man, this woman, and these children are worthy of the compassion with which they have inspired you.

These words have been sometimes classed as demonstrative pronouns. They are not, however, used instead of nouns, but they accompany them, and hence are really adjectives.

When it is thought necessary to call attention very distinctly and emphatically to a noun, *ci* and *là*, meaning *here* and *there*, are added to the noun which has *ce* placed before it; as *Cet enfant-ci*, This child here, or this very child; *Cet homme-là*, That man there, or that very man.

Masculine.			
ce livre-ci,	*this book.*	ce livre-là,	*that book.*
ces hommes-ci,	*these men.*	ces hommes-là,	*those men.*

We may note here that care must be taken to distinguish between this *ce* and *se*, a reflective pronoun, as well as *ses*, a possessive adjective which expresses the idea of possession by a person, from *ces*, the demonstrative adjective, which merely acts as an indicator of particular things; as *Dans ces temps d'incertitude l'homme a ses bons et ses mauvais jours*, In these times of uncertainty man has his good and his evil days.

There is a demonstrative pronoun, *ce*, which is always joined to the verb *être*, or followed by the pronouns *qui, que, quoi, dont*, that must not be confounded with this *ce*, which invariably precedes its noun and agrees with it. The chief use of that pronoun which is joined with *être* (*c'est*) is to point out the most important or emphatic word or words in the sentence; the emphatic word ought immediately to follow *c'est*: *C'est à pied que vous allez demain à Londres*, You *walk* to

London to-morrow; *C'est à Londres que vous allez demain,* You walk *to London* to-morrow; *C'est demain que vous allez à Londres,* You walk *to-morrow* to London.

The same rule holds good with regard to its use as an interrogative: *Est-ce à pied que vous allez demain à Londres? Est-ce à Londres que vous allez demain? Est-ce demain que vous allez à Londres?*

(2) *Possessive adjectives* modify the nouns before which they are placed, by indicating that the things of which they are the names are possessed by some one who is indicated by the possessive adjective. They are always placed before the substantives to which they refer, and agree with them in number, gender, and case, except that *mon, ton, son* are used instead of *ma, ta, sa,* before feminine nouns beginning with a vowel or *h;* as *mon âme,* my soul; *ton épouse,* thy wife; *son honnêteté,* his honesty. This is done to avoid the coming together of the two vowels; as *sa humeur.* Euphony in this case overcomes the claim of gender for recognition. *Son* and *sa* take the gender of the noun they qualify; as *son mari,* her husband; *son chapeau,* his or her hat; *sa femme,* his wife; *sa montre,* his or her watch. The possessive adjectives are—

Singular.		*Plural.*	
Mas.	*Fem.*	*Mas.* or *Fem.*	
Mon,	ma,	mes,	*my.*
Ton,	ta,	tes,	*thy.*
Son,	sa,	ses,	*his, her, its.*
Notre,	notre,	nos,	*our.*
Votre,	votre,	vos,	*your.*
Leur,	leur,	leurs,	*their.*

EXAMPLES.

Mas.	*Fem.*	*Plural.*
Mon père,	ma mère,	mes parents,
My father,	*my mother,*	*my relations.*
Ton frère,	ta sœur,	tes cousins,
Thy brother,	*thy sister,*	*thy cousins.*
Son enfant,	sa tante,	ses oncles,
Her child,	*his aunt,*	*his uncles.*
Notre livre,	notre plume,	nos hardes,
Our book,	*our pen.*	*our clothes.*
Votre habit,	votre oie,	vos oiseaux,
Your coat,	*your goose,*	*your birds.*
Leur coq,	leur poule,	leurs ânes,
Their cock,	*their hen,*	*their asses.*

Possessive adjectives are usually repeated before each noun which they specify or particularize. The common usuage is:—

When two adjectives having dissimilar meanings qualify the same noun, and thus really make the noun represent two distinct things, the possessive adjective is placed before each; as *Notre bonne et notre mauvaise fortune,* Our good and ill luck.

But when two or more adjectives are of nearly similar meaning, and thus really the same things are signified by the noun, the possessive adjective is only placed before the first; as *Nos belles et fertiles plaines,* Our beautiful and fertile plains.

(3) *Indefinite adjectives* qualify nouns by referring to them in a vague, general, and impersonal way. They are—

Singular.		*Plural.*		
Mas.	*Fem.*	*Mas.*	*Fem.*	
Aucun,	aucune,	aucuns,	aucunes,	*any.*
Autre,	autre,	autres,	autres,	*other.*
Certain,	certaine,	certains,	certaines,	*certain, some.*
Chaque,	chaque,	—	—	*each.*
Maint,	mainte,	maints,	maintes,	*many.*
Même,	même,	mêmes,	mêmes,	*same, self.*
Nul,	nulle,	nuls,	nulles,	*no, none.*
Pareil	pareille,	pareils,	pareilles,	*such.*
—	—	plusieurs,	plusieurs,	*several.*
Quel,	quelle,	quels,	quelles,	*what.*
Quelque,	quelque,	quelques,	quelques,	*a few, some.*
Quelconque,	quelconque,	quelconques,	quelconques,	*any, some.*
Tel,	telle,	tels,	telles,	*such.*
Tout,	toute,	touts,	toutes,	*all, every.*

These words obey the usual rules for the formation of the feminine and of the plural of adjectives.

EXAMPLES.

Aucun chemin de fleurs ne conduit à la gloire,	*No path of flowers leads to glory.*
Ils sont du même âge et de la même stature,	*They are of the same age and of the same stature.*
Je ne sais pas quel auteur a dit cela,	*I do not know what author has said that.*
Un tel homme est de nulle conséquence,	*Such a man is of no consequence.*
Chaque âge a certains devoirs,	*Each age has certain duties.*
Maintes femmes sont timides, toutes sont faibles,	*Many women are timid, all are weak.*
Nul jouet ne plaira à un garçon pareil,	*No toy will please such a boy (as he is).*

The above words are sometimes used adverbially; as *Il est tout changé,* He is quite changed; *les femmes et même les enfants,* the women and even the children. When used in this way, they do not agree with the noun, except *tout,* which changes for the sake of euphony before an adjective or a past participle in the feminine beginning with a consonant or *h* aspirate; as *Elles sont toutes changées,* They are quite changed.

(4) *Numeral adjectives* denote either (1) number or quantity, when they are called *cardinal;* or (2) rank or relative position, when they are called *ordinal.*

Cardinal numbers refer to collections of things, and enable us to say how many individuals there are in the collection; ordinal numbers enable us to arrange these individuals in their proper place, as first, second, &c. They will be found side by side in the following columns, with which the student should make himself thoroughly familiar:—

CARDINAL NUMBERS.	ORDINAL NUMBERS.
1 Un, *m.;* une, *f.*	1st premier, *m.;* première, *f.*
2 Deux (*dŭ*).	2nd deuxième (or second, *m.;* seconde, *f.;* pron. *sĕ-gon*).
3 Trois (*trwŏ*).	3rd troisième.
4 Quatre (*katr*).	4th quatrième.
5 Cinq (*sank*).	5th cinquième.
6 Six (*see* or *seess*).	6th sixième.
7 Sept (*set*).	7th septième.
8 Huit (*weet*).	8th huitième.
9 Neuf (*nŭf*).	9th neuvième.
10 Dix (*dee* or *deess*).	10th dixième.
11 Onze.	11th onzième.
12 Douze.	12th douzième.
13 Treize (*trayze*).	13th treizième.
14 Quatorze.	14th quatorzième.
15 Quinze.	15th quinzième.
16 Seize (*sayze*)	16th seizième.
17 Dix-sept.	17th dix-septième.
18 Dix-huit.	18th dix-huitième.
19 Dix-neuf.	19th dix-neuvième.
20 Vingt (*vant*).	20th vingtième.
21 Vingt-et-un.	21st vingt-et-unième.
22 Vingt-deux.	22nd vingt-deuxième.
23 Vingt-trois.	23rd vingt-troisième.
24 Vingt-quatre.	24th vingt-quatrième.
25 Vingt-cinq.	25th vingt-cinquième.
26 Vingt-six.	26th vingt-sixième.
27 Vingt-sept.	27th vingt-septième.
28 Vingt-huit.	28th vingt-huitième.
29 Vingt-neuf.	29th vingt-neuvième.
30 Trente.	30th trentième.
31 Trente-et-un.	31st trente-et-unième.
32 Trente-deux.	32nd trente-deuxième.
&c. &c.	&c. &c.
40 Quarante.	40th quarantième.
41 Quarante-et-un.	41st quarante-et-unième.
42 Quarante-deux.	42nd quarante-deuxième.
&c. &c.	&c. &c.
50 Cinquante.	50th cinquantième.
51 Cinquante-et-un.	51st cinquante-et-unième.
&c. &c.	&c. &c.
60 Soixante.	60th soixantième.
61 Soixante-et-un.	61st soixante-et-unième.
62 Soixante-deux.	62nd soixante-deuxième.
&c. &c.	&c. &c.
70 Soixante-dix.	70th soixante-dixième.
71 Soixante-onze.	71st soixante-onzième.
72 Soixante-douze.	72nd soixante-douzième.
73 Soixante-treize.	73rd soixante-treizième.

CARDINAL NUMBERS.	ORDINAL NUMBERS.
74 Soixante-quatorze.	74th soixante-quatorzième.
75 Soixante-quinze.	75th soixante-quinzième.
76 Soixante-seize.	76th soixante-seizième.
77 Soixante-dix-sept.	77th soixante-dix-septième.
78 Soixante-dix-huit.	78th soixante-dix-huitième.
79 Soixante-dix-neuf.	79th soixante-dix-neuvième.
80 Quatre-vingt.	80th quatre-vingtième.
81 Quatre-vingt-un.	81st quatre-vingt-unième.
82 Quatre-vingt-deux.	82nd quatre-vingt-deuxième.
83 Quatre-vingt-trois.	83rd quatre-vingt-troisième.
84 Quatre-vingt-quatre.	84th quatre-vingt-quatrième
85 Quatre-vingt-cinq.	85th quatre-vingt-cinquième.
86 Quatre-vingt-six.	86th quatre-vingt-sixième.
87 Quatre-vingt-sept.	87th quatre-vingt-septième.
88 Quatre-vingt-huit.	88th quatre-vingt-huitième.
89 Quatre-vingt-neuf.	89th quatre-vingt-neuvième.
90 Quatre-vingt-dix.	90th quatre-vingt-dixième.
91 Quatre-vingt-onze.	91st quatre-vingt-onzième.
92 Quatre-vingt-douze.	92nd quatre-vingt-douzième.
93 Quatre-vingt-treize.	93rd quatre-vingt-treizième.
94 Quatre-vingt-quatorze.	94th quatre-vingt-quatorzième.
95 Quatre-vingt-quinze.	95th quatre-vingt-quinzième.
96 Quatre-vingt-seize.	96th quatre-vingt-seizième.
97 Quatre-vingt-dix-sept.	97th quatre-vingt-dix-septième.
98 Quatre-vingt-dix-huit.	98th quatre-vingt-dix-huitième.
99 Quatre-vingt-dix-neuf.	99th quatre-vingt-dix-neuvième.
100 Cent.	100th centième.
101 Cent-un.	101st cent-unième.
102 Cent-deux.	102nd cent-deuxième.
200 Deux-cents.	200th deux-centième.
1000 Mille.	1000th millième.
1001 Mille-un.	1001st mille-unième.
10000 Dix-mille.	10000th dix-millième.

The ordinal numbers become adverbs by adding *ement* or *ment;* as *premièrement*, *secondement* or *deuxièmement*, *troisièmement*, &c.

There are three other sorts of numbers, which may be called fractional, collective, and proportional.

(1) *Fractional*, expressing a part of a whole—

Demi, Demie, Moitié	*the half.*	Le quart,	*the fourth.*
		Les deux tiers,	*two-thirds.*
		Les trois quarts,	*three-fourths.*
Le tiers,	*the third.*	Un cinquième,	*one-fifth.*

(2) *Collective*, denoting a certain number or quantity thought of as a whole—

Une couple,	*a couple.*	Une centaine,	*a hundred.*
Une douzaine,	*a dozen.*	Un millier,	*a thousand.*

(3) *Proportional*, holding a certain quantitative relation to one another and to some whole—

Le double,	*the double.*	Le quadruple,	*the fourfold.*
Le triple,	*the treble.*	Le centuple,	*the hundredfold.*

The following miscellaneous observations will supply guidance in the use of numerals:—

Numeral adjectives are of either gender, except *un*, *premier*, and *second*, which add *e* in the feminine.

The last letter of *cinq*, *six*, *sept* (*p* mute), *huit*, *neuf*, *dix* is pronounced when these numerals are at the end of a sentence, or are followed by a word beginning with a vowel.

Note that *et* (and) is added between the numerals in 21, 31, 41, 51, and 61, but not in 71, 81, 101, 1001, which are *soixante-onze*, *quatre-vingt-un*, *cent-un*, *mille-un.* Of course the *t* of *et* is not sounded; *e.g. vingt-et-un* is pronounced *van-tay-un.*

When the smaller numbers are compounded with others a hyphen is used; as *dix-sept*, 17, *quatre-vingt-seize*, 96.

Notice that the French have no single numeral for 70, 80, and 90: the numbers go on from 60 to 79; thus, sixty-ten = 70, sixty-eleven = 71, &c., to sixty-nineteen = 79; then fourscore = 80, fourscore-one = 81, &c., to fourscore-nineteen = 99; 0 is called *zéro.*

Except in the case of *le premier* and *le second*, the ordinal numbers are formed from the cardinal ones, by (1) changing *e* mute into *ième* for those which end with a vowel; as *quatre, quatrième;* by (2) adding *ième* to those which end in any other consonant than *f;* as *trois troisième; dix, dixième*, except *cinq*, which takes *u* before *ième*, *cinquième;* and (3) by changing those which end in *f* final into *v* before adding *ième;* as *neuf*, *neuvième.*

In English, people always use the ordinal numbers when they put a date to anything; in French, on the contrary, the cardinal is most commonly used (except the first, which is ordinal); thus, the French say *le premier Janvier*, the first of January; *le cinq Mai*, the fifth of May.

The English use of the ordinal numbers with an article after the Christian name of a sovereign differs from that of the French, who use the cardinal (the first excepted), and never put an article before them; as *Henri premier*, *Henri deux*, *Henri trois*, *Henri quatre*, Henry the first, Henry the second, Henry the third, Henry the fourth.

When two numerals are joined together the larger takes the first place in French; thus we say *vingt-cinq*, *vingt-six*, and not *cinq et vingt*, five and twenty, *six et vingt*, six and twenty, as is sometimes done in English.

When several numbers meet together the French do not put any conjunction between them; thus they say *cent-vingt*, *cent-trente*, and not *cent-et-vingt*, *cent-et-trente*, a hundred and twenty, a hundred and thirty.

The English word thousand is rendered in French (1) by *mil*, with one *l* only, when it is used for the date of the year, and (2) by *mille*, with *lle*, in other cases; as *l'an mil huit-cent quatre-vingt-huit*, in the year one thousand eight hundred and eighty-eight.

Mille, meaning a thousand, never takes an *s*, so we use *deux mille*, two thousand; but when *mille* means a mile it takes *s* in the plural; as *deux milles*, two miles.

When *cent* and *mille* are followed by a number they are never in French preceded by the word *un*, as they are in English by the word one; thus, the French say *cent cinquante* for one hundred and fifty.

In speaking of several score or hundred, the words *vingt* and *cent* take an *s* only when not followed by another numeral; thus *trois-cents soldats*, three hundred soldiers; but *trois-cent vingt-six soldats*, three hundred and twenty-six soldiers.

The word *million* is a collective noun, and takes the plural termination; as *deux millions*, *dix millions.*

Numbers not mentioned in these observations are indeclinable.

The French way of specifying time is as follows:—

Midi,	*noon.*
Minuit,	*midnight.*
Cinq heures,	*five o'clock.*
Cinq heures dix (or et dix minutes),	*ten minutes past five.*
Cinq heures un quart (or et un quart).	*quarter past five.*
Cinq heures et demie,	*half past five.*
Six heures moins un quart,	*quarter to six.*
Six heures moins dix (*minutes* understood).	*ten minutes to six.*

Note that *demi*, half, takes the feminine when *heure* is expressed or understood; but in a sentence like *midi et demi* (12.30 p.m.) it is masculine, to agree with *midi.*

CHAPTER VII.

PRONOUNS—PERSONAL, DEMONSTRATIVE, POSSESSIVE, INDEFINITE, RELATIVE, INTERROGATIVE.

Pronouns are words used instead of nouns. In certain instances they vary to indicate number, gender, and case.

They may be arranged in six classes:—I. Personal; II. Demonstrative; III. Possessive; IV. Indefinite; V. Relative; VI. Interrogative.

I. *Personal pronouns* are those which represent either persons or things in their relation to verbs. They are distinguished as belonging to three persons.

The first denotes the person who speaks; as *Je vais*, I go; *J'enseigne*, I teach.

The second denotes the person spoken to; *Tu iras*, Thou wilt go; *Vous enseignez*, You teach.

The third denotes the person or thing spoken about; as *Il va*, He goes.

Pronouns are called (1) conjunctive, or (2) disjunctive, according to their position in the sentence.

(1) *Conjunctive pronouns* accompany a verb, and are not separated from it by a conjunction or preposition expressed or understood.

CONJUNCTIVE PERSONAL PRONOUNS.

Nominative (subject).		Dative (indirect object).		Accusative (direct object).	
Je,	*I.*	me,	*to me.*	me,	*me.*
Tu,	*thou.*	te,	*to thee.*	te,	*thee.*
Il,	*he or it.*	lui,	*to him or it.*	le,	*him or it.*
Elle,	*she or it.*	lui,	*to her or it.*	la,	*her or it.*
Nous,	*we.*	nous,	*to us.*	nous,	*us.*
Vous,	*you.*	vous,	*to you.*	vous,	*you.*
Ils,	*they (mas.)*	leur,	*to them.*	les,	*them.*
Elles,	*they (fem.)*	leur,	*to them.*	les,	*them.*

Se expresses all numbers, genders, and cases of *himself, herself, itself, each*, or *one another*. It refers only to the third person, and is often called a reflective pronoun.

En stands for *of* or *from him, her, it, them;* it also means *thence*.

Y stands for *to him, her, it, them;* it also means *there* or *thither*.

En, however, is commonly used with the meaning *of* or *from it*, and *y* with the meaning *to it* or *thither*.

Notice that some of the above pronouns have the same form as the definite article *le, la, les;* as a rule these words will be found to be articles when they accompany nouns, and pronouns when they accompany verbs.

The above pronouns always follow the verb in interrogative sentences; as *Avez-vous une plume?* Have you a pen? They also follow a verb when it is in the imperative; as *Donnez-le leur*, Give it to them (except in a negative imperative sentence, when it precedes the verb; as *Ne le donnez pas*, Do not give it). In all other cases they precede the verb.

When two or more pronouns come together they are arranged in order according to the following rules:—The subject comes first, next the indirect object, then the direct object; as *Je vous le donne*, I give it to you (literally, I to you it give); but if there are two objects, and both are in the third person, then the direct precedes the indirect object; as *Je le lui donne*, I give it to him (literally, I it to him give).

The *e* of *je* is always omitted before a vowel; as *j'ai*, I have.

(2) *Disjunctive pronouns* are those which can be used alone, or, if in a sentence, are separated from the verb by a conjunction or preposition expressed or understood.

DISJUNCTIVE PERSONAL PRONOUNS.

	As Subject.	As Object.		As Subject.	As Object.
Moi,	*I,*	*me.*	Nous,	*we,*	*us.*
Toi,	*thou,*	*thee.*	Vous,	*ye* or *you,*	*you.*
Lui,	*he,*	*him.*	Eux,	*they,*	*them.*
Elle,	*she,*	*her.*	Elles,	*they (f.),*	*them (f.)*

The above can be made reflective by adding *même*, self, to the singular, and *mêmes* to the plural; as *toi-même*, thyself, *vous-mêmes*, yourselves. This can also be expressed by *soi*, himself, herself, itself, one's self.

These pronouns always follow a verb when they are its object, and care must be taken not to confuse some of them with the conjunctive, as they are the same in form. They are often used to emphasize the latter, as *Moi je dis*, I say; and they are always used in answering a question; as *Qui parle? Moi.* Who speaks? I.

This form of the pronoun is employed in expressing mine, thine, &c., when accompanying the verb *être;* as *C'est à moi*, It is mine.

II. *Demonstrative pronouns* are used to point out clearly the person or thing referred to, and agree with their nouns in gender and number.

DEMONSTRATIVE PRONOUNS.

Singular. Mas.	Singular. Fem.	Plural. Mas.	Plural. Fem.	
Ce,	—	—	—	*it.*
Celui,	celle,	ceux,	celles,	*this, that, these, those.*
Celui-ci or ceci,	celle-ci or ceci,	ceux-ci,	celles-ci,	*this (here), these.*
Celui-là or cela,	celle-là or cela,	ceux-là,	celles-là	*that (there), those.*

III. *Possessive pronouns* express the idea of ownership; they are formed from the possessive adjectives.

POSSESSIVE PRONOUNS.

Mas. Sing.	Fem. Sing.	
Le mien,	la mienne,	*mine.*
Le tien,	la tienne,	*thine.*
Le sien,	la sienne,	*his, hers, its.*
Le nôtre,	la nôtre,	*ours.*
Le vôtre,	la vôtre,	*yours.*
Le leur,	la leur.	*theirs.*

The plural is formed by adding *s* to each of the above forms.

The articles which precede these pronouns combine with the prepositions *de*, of or from, and *à*, to, and become *du, de la, des*, and *au, à la, aux;* as *du mien* or *de la mienne*, of mine; *au tien* or *à la tienne*, of thine; *des vôtres*, of yours; *aux leurs*, to theirs.

These pronouns agree in number and gender not (as in English) with the possessor, but with the thing possessed. They are used *instead* of nouns:—but when my, thy, his, &c., occur *before* a noun they are translated by the possessive adjectives *mon, ton, son*, &c.

Ma *plume est grande mais* la sienne *est plus grande, My* pen is large but *his* (or hers) is larger.

Note that *le nôtre*, ours, and *le vôtre*, yours, take a circumflex over the *o*, to distinguish them from the possessive adjectives.

IV. *Indefinite pronouns* refer to nouns in a vague and general way. A number of them are simply forms ot the indefinite adjectives (to which refer), and they vary to indicate number and gender.

The variable ones are—

Aucun,	*any; with* ne, *none.*	Quelconque,	*whatever.*
Chacun	*each* or *every one.*	Quelque . . que,	*whatever.*
Nul (ne),	*no one.*	Rien,	*nothing.*
Quelqu'un,	*some one.*	Tel,	*such a one.*

The invariable ones are—

Autres,	*others.*	Personne (ne),	*nobody.*
Autrui,	*other people.*	Plusieurs,	*several.*
On,	*one, people, they, &c.*	Quiconque,	*whoever.*

Tout, *everything, all.*

There are also a number of sentences which translate English pronouns; as—

L'un l'autre,	*one another.*	Qui que ce soit,	*whoever (it may be)*
L'un et l'autre,	*both.*	Quoi que ce soit,	*whatever (it may be).*
L'un ou l'autre,	*either.*		
Ni l'un ni l'autre,	*neither.*	Tout le monde,	*everybody.*

Tout ce qui (*or* que), *whatever.*

Like the negative adjectives, the negative pronouns *aucun, nul, personne, rien*, meaning no, none, nothing, &c., require the verb to be preceded by *ne;* as *Personne ne viendra*, No one will come; *Rien ne suffira*, Nothing will suffice.

Quelque, whatever, before a verb separates into *quel que*, and *quel* varies according to the gender and number of the noun it refers to; as *Quelle que soit sa beauté*, Whatever may be her beauty.

V. *Relative pronouns* refer to previously-named nouns, and show that these nouns are related to part of the sentence which follows; they therefore connect this part of the sentence with the preceding noun, which is called the *antecedent*.

There is only one relative pronoun which varies to indicate gender and number, viz.:—

Singular.

Mas.	Fem.	
Lequel,	laquelle,	*who, which, what.*
Duquel,	de laquelle,	*of* or *from whom, which, what*
Auquel,	à laquelle,	*to whom, which, what.*

Plural.

Mas.	Fem.	
Lesquels,	lesquelles,	*who, which, what.*
Desquels,	desquelles,	*of whom, which, what.*
Auxquels,	auxquelles,	*to whom, which, what.*

This form is chiefly used when the speaker wishes to express himself very clearly; it is also used to translate the relative pronoun when it is preceded by a preposition and refers to a thing; as *La maison de laquelle je suis le propriétaire*, The house of which I am the proprietor.

The invariable pronouns are—

Qui,	*who, which, what.*	Dont,	*whose, of whom, of which.*
Quoi.	*which.*	Que,	*whom, which, that.*

The same form of these is used for either gender and for both numbers.

Qui is used as the subject of a verb, and refers both to persons and things, but after a preposition it refers to persons only; as *L'homme qui rit*, The man who laughs; *La femme qui parle*, The woman who speaks; *Le chapeau qui est là*, The hat which is there; *Les hommes à qui vous parlez*, The men to whom you speak.

Quoi is used (instead of *qui*) after a preposition when referring to things; as *La chose à quoi* (or *à laquelle*) *vous pensez*, The thing of which you think.

Dont has the same meaning as, and may be used instead of, *de qui*, of whom, *de quoi*, of which, and *duquel* or *de laquelle*, whose or of which.

Que is the objective case of *qui* and *quoi*, and the final *e* is cut off before a vowel; as *La femme que vous voyez*, The woman whom you see; *L'enfant qu'il aime*, The child which he loves.

VI. *Interrogative pronouns* are practically relative pronouns used in asking a question. All the relative pronouns are used in this way except *dont*, whose or of which.

In using the various forms of *lequel* the first syllable is often omitted, and the word becomes *quel, quelle, quels, quelles*, but this only happens when it immediately precedes a noun; as *Quelle femme?* Which woman? And in this case it might be called an interrogative adjective.

Qui refers to persons only, and means both who and whom. It is often followed by the phrase *est-ce qui;* as *Qui est-ce qui parle?* literally, Who is it who is speaking? *Qui voyez-vous?* Whom do you see?

Que and *quoi* only refer to inanimate objects, and *quoi* is always used with a preposition or quite alone; as *Que portez-vous?* What are you carrying? *De quoi parlez-vous?* Of what are you speaking? *Quoi?* What? There is one case in which *que* may refer to a person, *i.e.* when it forms part of the expression *qui est-ce que* as the object of a verb; *e.g. Qui est-ce que vous voyez?* Whom do you see?

Before the verb *être*, to be, whose (as a relative or interrogative) is translated by *à qui;* as *à qui est cela?* Whose is that?

NATURAL PHILOSOPHY.—CHAPTER VII.

THE MECHANICAL POWERS: THE INCLINED PLANE, WEDGE, AND SCREW.

THE inclined plane is a plane inclined to the horizon, or making an angle with it. It is considered one of the simple mechanical powers; and the double inclined plane makes the wedge. The inclined plane is employed to advantage in raising heavy bodies in certain positions, diminishing their weights by their being placed on the inclined plane. Its fundamental law of action is that of the composition and resolution of forces, and may be expressed as follows: *the power gained by the inclined plane is in proportion as the length of the plane is to its height.* That is, when a weight, W (fig. 1, Plate IV.), is sustained by an inclined plane A C, by a power P acting in a direction parallel to the plane, then the weight W is to the power P in the same proportion as the length of the plane A C is to its height B C; that is, W : P : : C A : C B. For example, let the line M O represent the force which the weight W of the mass K L exerts, acting vertically downwards; this force may be decomposed into two others: one, M N, acting at right angles against the plane, and representing the *pressure* which the weight exerts against the plane, and which is counterbalanced by the reaction of the plane; the other, E R, represents the component which tends to move the weight down the plane, and this component has to be held in equilibrium by the weight P, equal to it, and acting in the opposite direction. As the triangle E M R is similar to the triangle C A B, and the sides E R and E M are in the same proportion as C B and C A, therefore, as the line E R represents the power, and the line E M the weight, C B : C A : : P : W; and since the ratio $\frac{CB}{CA}$ is the sine of the angle C A B, represented by x, P = W sin x. The most advantageous way of employing a power to sustain a weight on an inclined plane, is when the power acts in a direction parallel to the surface of that plane. Again, from the similarity of the triangles E M R and C A B, M E : M R : : A C : A B, showing that the weight of K L is to its perpendicular pressure upon the inclined plane in the proportion of the length of the plane to its base. In general, therefore, the sides of the triangle formed by an inclined plane, its base, and its height, are respectively proportional to a weight at rest upon it, the pressure of that weight upon the plane, and the power necessary, when acting parallel to it, to maintain the weight at rest. By similar reasoning, the power necessary to keep the weight at rest on an inclined plane may be ascertained when the power acts in a direction parallel to the base.

Let the force P (fig. 1, below) act on the body in the direction W G, parallel to base A C. Draw W E perpendicular to A C, representing the weight in magnitude and direction; and W F perpendicular to A B, meeting A C in F. Therefore, in the triangle W E F, W E is equivalent to W F and E F, of which W F shows the pressure on the plane A B, and E F the power in the direction W G, sufficient to retain the body at rest. Now, the triangle W E F is similar to the triangle A B C, so that W E : E F : : A C : B C, that is, the weight is to the power as the base to the height of the plane. When the power P acts parallel to the plane, the weight is to the power as the length to the height of the plane. Therefore, a given power will support a greater weight in the latter case, inasmuch as the length of

Fig. 1.

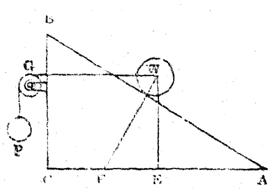
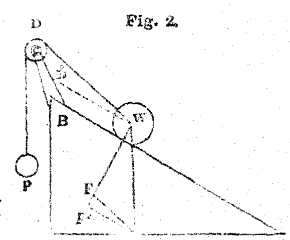


Fig. 2.



the plane is greater than the base. Again, W E : W F : : A C : A B, or, the weight W is to its pressure on the plane A B as the base is to the length of the plane, so that the pressure on the plane is greater than the weight of W itself, whereas, in the former case, it is less. Again, if the power be applied in any direction above that of the plane, the pressure of the weight on the plane is less than the weight itself, but the power required to balance the weight is also greater than is required when it acts in a direction parallel to the plane, as it tends to raise the weight off it. Let the weight W (fig. 2) be at rest on the plane A B by the force P acting on W in the direction W D, at an angle with A B, receding from it towards D. Draw W E perpendicular to A C, representing the weight of W; draw W F perpendicular to A B, and E F parallel to W D, then is W E equivalent to W F and F E; these respectively represent the pressure of the weight on the plane, and the force acting on the cord W D, which is counteracted by the power P. If the power had been applied in the direction W D^2, parallel to A B, then E F^2 would be drawn parallel to A B, or perpendicular to W F; therefore, W F^2 would have been the pressure on the plane, and E F^2 the power required. As W F is less than W F^2, the pressure on the plane is less in the first case than in the second, because E F is greater than E F^2. Therefore, the power required to keep W at rest, when acting in a direction rising above the plane, is greater than that required when W acts in a direction parallel to the plane.

Thus, in a series of inclined planes having the same altitude, the longer they are the less power is necessary to balance a given weight laid upon them. Let A B and A C (fig. 2, Plate IV.) be two planes of the same height A D, joined at that line; and let the two weights, M and M′, upon these planes

respectively balance one another over the pulley E; the force exerted by each of them upon the cord to maintain this equilibrium will therefore be the same. But as the power is to M in the proportion of A D to A B, and to M′ as A D to A C, the weights M M′ are in the proportion of the lengths of the planes on which they lie, or M : M′ : : A B : A C; so that if A B be 12 inches, and A C 6 inches, and if M be 10 lbs., then M′ will be 5 lbs. This property of the compound inclined plane was first demonstrated by Simon Stevin, a Flemish mathematician of Bruges. His simple method of proof was by supposing a uniform endless chain hung over the double plane, and hanging in a curve below the points B C. The chain in this position is at rest. If the part below the points B C be removed, the remaining parts lying along A B and A C will continue at rest, since the hanging part acted with equal force on the points B C; and therefore, if these two equal and opposite forces were removed from the parts A B, A C, the equilibrium of these portions of chain remains unaffected. Therefore, the weights of these parts must be in proportion to the lengths of the planes A B, A C, and substituting single weights for the chains they still balance one another, being in the proportion of the length of the planes on which they rest. In the examples given no allowance has been made for the friction of the surfaces in contact. For cylindrical bodies the friction is small as they roll on the plane. But for flat bodies which rub it is considerable; and, that the power may be applied to the best advantage, its direction should not be parallel to the plane, but should form a certain angle with it, so as to partly relieve the friction.

The inclined plane is distinct from the lever in its mode of operation, as there is no actual motion round a centre, yet in another and equally important sense it is identifiable with the lever. Let W (fig. 3, below) be a circular body, resting on the plane A B, of which A C is the height. Draw W F in the direction of the force applied parallel to A B, and W E perpendicular to C B, representing the weight W; draw W F perpendicular to A B, and F G perpendicular to W E. Now, the perpendicular W F will always meet the plane A B at F, the point of contact with the cylinder. And again, the whole weight of the body may be considered to be gathered into the centre W, and to act in the vertical line W E. As it is immaterial at what point in W E the force acts, let it be supposed to act at G. Then F G becomes in effect one arm of a bent lever, F being the fulcrum, and the force at G the weight or resistance; F W is the other arm, at the extremity, W, of which the power P acts. Therefore, W E represents the weight, and is equivalent to W F and F E, of which F E, parallel to W P, represents the power P. The triangles W E F and W F G are similar to each other, so that W E : E F : : W F : F G, or W E × F G = E F × W F. But W E × F G is the moment of the force W E in reference to the point F, and E F × W F is the moment of the force E F, acting along W P, in reference to the same point F; and, therefore, W F G is virtually a bent lever, of which F is the fulcrum, so that the conditions of equilibrium on an inclined plane may be established on the principle of the lever. If F W be produced to X, and the force act at

Fig. 3.

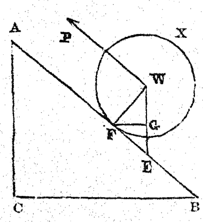
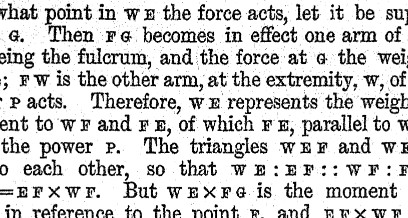
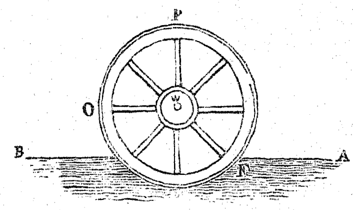


Fig. 4.



X parallel to A B, it will have its moment doubled, since F X is double F W, and to balance the same weight only one-half the power becomes necessary. This explains the advantage of the method often employed for raising hogsheads a few feet high into warehouses. Two planks (fig. 4) are laid at the required inclination upon the steps, and two ropes are passed under the hogshead, and returned over it into the warehouse. Manual power is applied at the ropes, by which the hogshead is raised to the floor of the store. In this way two men are able to raise the weight, while four men must be employed to raise it by simply pushing from behind. The wheels of a cart when stuck in the mud present a similar example. Fig. 5 represents a wheel imbedded to a depth E, and supposed to be moving towards A; then E being the lowest point, and F where it meets the surface, the space E F is an inclined plane

Fig. 5.

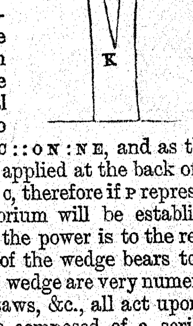


to be ascended before the wheel is drawn out from the mud. The power of the horse being communicated through the shafts, acts on the centre W of the wheel. But when manual power is employed, the most advantageous point at which to apply their power is at or near P. When applied at or near O, as is frequently done, much power is wasted in simply raising the load without a corresponding advance. The inclined plane is employed for raising great weights through small heights. Flights of steps are up-hill work made easy. A horse drawing a load in a serpentine course when ascending a steep road is another illustration; the road being in effect divided into a series of inclined planes of less inclination than the road itself.

THE WEDGE.

The wedge is generally in the form of a three-sided prism of iron or steel, one of whose angles is very acute, and it is employed for a great variety of purposes in overcoming the force which holds the two parts of a body together, or in the raising of weights or obstacles. Let A B C be a smooth isosceles wedge (fig. 6). The side A B is the *back;* the vertex of the angle A C B, which the two faces A C and B C make with each other, is the *edge;* and the faces A C and B C the *sides* of the wedge. The power P is generally applied at right angles to the back. In the figure the wedge A C B is represented in the act of cleaving a block of wood, G K H, the cohesion between the fibres of which constitutes the resistance to be overcome. The wedge A C B is at rest under three forces—namely, the pressure at P, and the reaction upon the two surfaces C A and C B; since the forces balance, they must meet in one point N, and since the wedge is isosceles, the reaction on the sides must be equal. The cohesion to be overcome is represented by E N and F N, which are at right angles to the two faces of the wedge; by completing the parallelogram E N F, the diagonal O N will represent the resultant of the forces tending to drive the wedge out, and the force which must be applied to keep the wedge in equilibrium must therefore be equal to O N; but as N E O is similar to the triangle A C B, therefore A B : A C : : O N : N E, and as these lines are equivalent to the pressure applied at the back of the wedge and the pressure on the face A C, therefore if P represents the former and Q the latter, equilibrium will be established when P : Q : : A B : A C, that is, when the power is to the resistance in the same ratio as the back of the wedge bears to one of the sides. The applications of the wedge are very numerous: nails, awls, needles, scissors, axes, saws, &c., all act upon the principle of the wedge. The saw is composed of a series of

Fig. 6.



wedges, and the finest cutting instrument may be regarded as a saw of which the teeth are very minute. For instance, the lancet may be pressed against the skin without penetrating, but the instant it is drawn along it cuts into the flesh. The carpenter's plane, again, removes the shaving from the surface of the plank by a wedging action. As illustrative of the unlimited power of the wedge, ships lying in dock are easily lifted up by means of wedges driven under their keels. The power of the wedge is frequently employed for binding together separate parts of machinery, as in the familiar example of the butt and strap. Fig. 7, *a* is the butt end of a connecting rod, *b b* the strap embracing the bush *c* and binding it to the butt, *d d* the cutter in the form of a wedge of very small taper, which passes through slot holes in the butt and strap; it is driven fast into its place and binds the whole together; the piece *e*, termed the gib, secures the ends of the strap and prevents them from spreading.

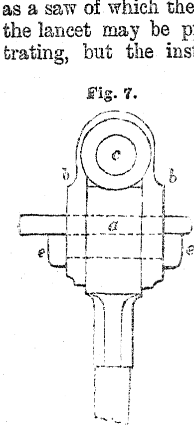


Fig. 7.

THE SCREW.

The screw, one of the six mechanical powers, is chiefly employed in pressing or squeezing bodies into compact masses; it is also frequently made use of in raising heavy weights. It multiplies the extent of the action of the inclined plane by presenting in effect a continued series of planes. The screw (fig. 3, Plate IV.) is a spiral thread or groove cut round a cylinder, and everywhere making the same angle with the length of the cylinder; so that if the surface of the cylinder, with this spiral thread wrapped continuously round it, were unfolded and stretched out into a plane, the spiral threads would form a succession of straight parallel lines (fig. 4), whose length would be to their height as the circumference of the cylinder is to the sum of the distances between all the successive threads of the screw; this is evident, as in making one revolution round the cylinder the spiral rises along the cylinder the distance between the two contiguous threads. Thus the distance between the threads F F′ F″ (fig. 3) is the distance between the parallel lines on the plane (fig. 4), and the rise F F′ is the distance *c b*. The *pitch of the screw* is the space through which the spiral thread rises in one revolution round the cylinder; the triangle *d b c* (fig. 4) is the space it rises, the line *b c* being equal to the distance between any two threads, and the line *d b* is the pitch.

Screws are frequently constructed with threads of which the cross section is triangular (fig. 3, Plate IV.); others, again, have the screw thread as a projecting rim of a certain definite form, running round the cylinder (fig. 5); this form of screw thread is chiefly used in machinery. The screw thread commonly works in a *nut* (shown in figs. 3, 5), or against the teeth of a wheel. A screw nut is an exact counterpart of the screw, having a recessed part into which the projecting rim accurately fits. For the purpose of communicating motion to any piece of machinery, the external screw is made long enough to give the required traverse, as A B (fig. 6, Plate IV.), while the internal screw or nut is usually short, as at E, embracing some three or more threads of the external screw. In their application to machinery, either of them is made stationary in reference to the other, the latter being the one that receives the motion. Thus, in the common screw press (fig. 6) the nut E works on the sole of the press, and the screw bears upon it while rising; while in fig. 7, the screw A B is fixed to the upper board, and the nut E revolves it. Again, in the clamp A (woodcut, fig. 8) the internal screw is fixed, and the external one movable; while, on the other hand, at B, which represents a micrometer screw, it will be observed that while the screw is confined by a collar at the neck, the nut slides along it between two cheeks.

Fig. 8.

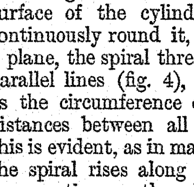
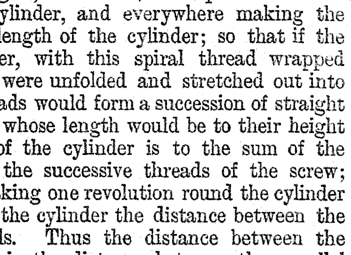
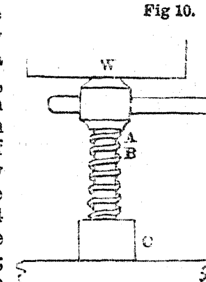


Fig. 9.



The action of the screw will be understood by reference to fig. 9; A B C, D E F are two inclined planes, or half-wedges, placed so that the planes, A C, D F, may be in contact, and the bases, B C and E F, parallel to each other. Let W represent a weight placed on the surface E F, and confined by pins moving in slotted upright guides, so that it can only move in a vertical direction. If a sufficient force, P, is applied to the back of the plane, E D, this plane will slide forward on the inclined surface A C, and the weight W will be elevated. This elevation cannot, however, exceed the height E D, which is the depth of the plane, or the distance between the threads of a screw, in which the pitch is represented by the line C A. Therefore, the screw being an inclined plane, or half-wedge, whose height is the distance between two threads, and its base the circumference of the screw; and the force in the horizontal direction being to that in the vertical one as the height of the plane, or distance of the two threads, is to the base of the plane or circumference of the screw; the power is to the pressure as the distance of two threads is to that circumference. By the use of a handle, or lever, the gain in power is increased in the proportion of the radius of the screw to the radius of the power; therefore the power P is to the pressure W (fig. 10) as the distance of the threads A B is to the circumference described by the power; that is, $P \times W = p \times l$, in which p is the pitch and l the circumference described by the power. It is therefore easy to compute the force of any machine moved by a screw, whose threads, say, are each a quarter of an inch asunder, or a pitch equal to one quarter of an inch. Let the screw A B (fig. 6, Plate IV.) be turned by a lever E C, 4 feet long from E the centre of the screw to C; then if the natural force of a man, by which he can lift, pull, or draw, be 150 lbs., and it be required to determine with what force the screw A B will press upon the upper board when the man turns the lever C E with his whole force, the diameter of the power being 4 feet, or 48 inches, its circumference $48 \times 3{\cdot}1416$, or about $150\frac{4}{5}$ inches, and the pitch of the threads being $\frac{1}{4}$ inch; therefore the power is to the pressure as 1 to $603\frac{1}{5}$; but the power is equal to 150 lbs., therefore $1 : 603\frac{1}{5} :: 150 : 90480$; and consequently the pressure upon the upper board is equal to a weight of 90480 lbs., independent of the friction of the screw, which is sometimes very great.

Fig 10.



The power in the screw is increased as the pitch or inclination of the plane forming its thread is diminished, and as its radius is less in comparison to the length of the lever at the extremity of which the power is applied. It is, however, often practically inconvenient to increase the length of the lever employed; and if the threads of the screw be cut too fine, they become too weak to support the pressure. A compound arrangement of the screw is therefore employed, by which power is gained. This is shown at fig. 7, Plate IV.: a screw, D C, is cut upon the outside of a cylinder, and a corresponding *internal* screw is cut in the nut A B. The cylinder upon which the external screw, D C, is cut is also hollow, with a thread cut in it corresponding to the thread upon the second cylinder, E D. The screw D C revolves in the nut A B, while the cylinder, E, is kept from revolving by its

NATURAL PHILOSOPHY.

PLATE IV.

INCLINED PLANE AND SCREW.

Fig. 1.

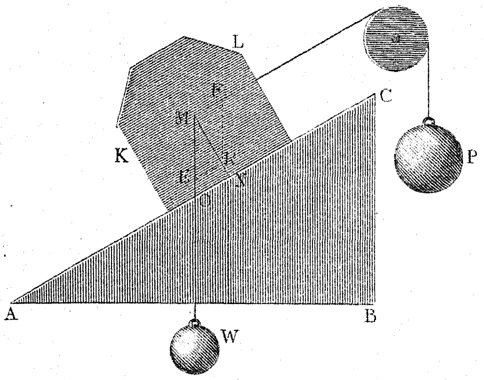


Fig. 2.

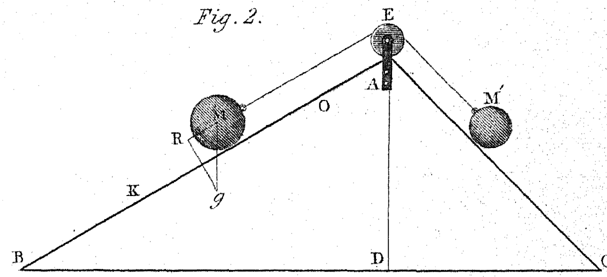


Fig. 3.

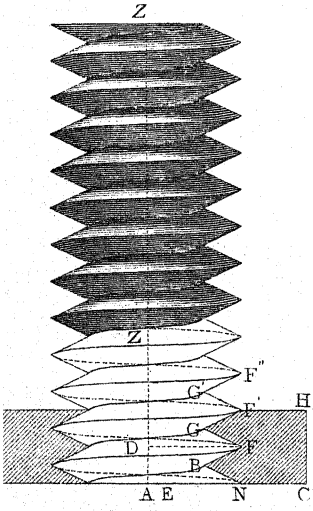


Fig. 4.

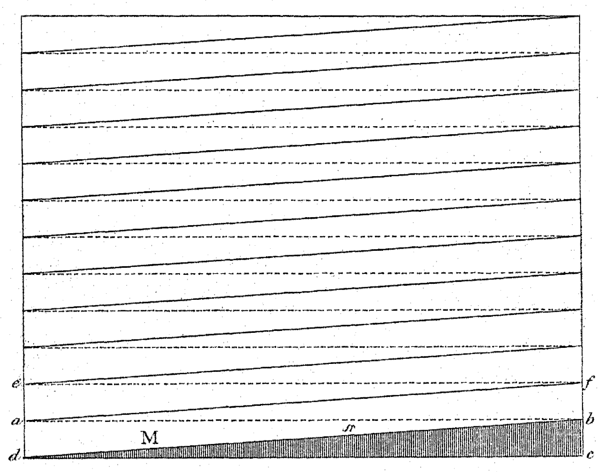


Fig. 5.

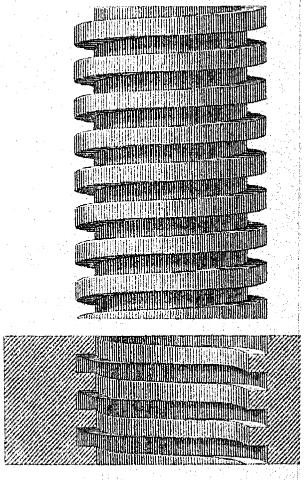


Fig. 6.

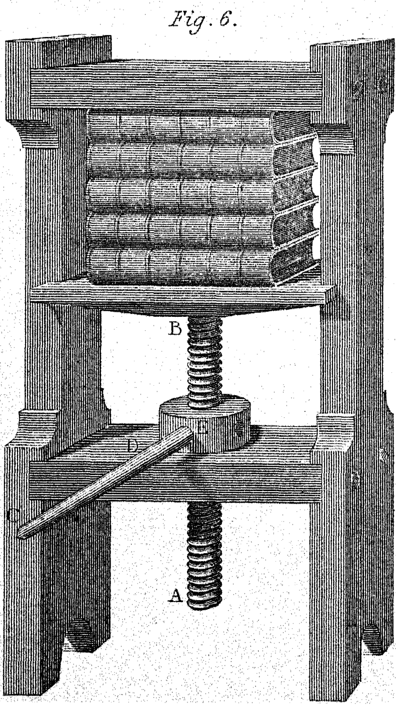
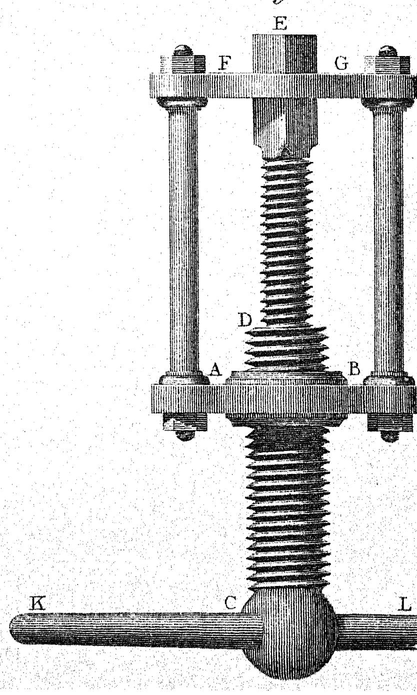


Fig. 7.



square shoulders, but it has a vertical movement through the sole plate, F G, of the fixed frame, F G A B; the power is applied at K by means of the lever K C L. If the screws upon the two cylinders are of the same pitch, and the screw A D turned by the lever K C, then the screw E would descend just as much as the screw C D would rise, and the head of E, which exerts the pressure, would remain stationary. But if the pitch of the threads upon E be less than the pitch of the screw D C, then in each revolution of the lever K C, the cylinder E will either be raised or depressed through a space equal to the difference of the pitches of the two screws; and there is equilibrium when the power is to the weight as the difference of the pitches of the threads is to the circumference described by the power.

Other applications of the screw are made in machinery in the instance of the worm wheel, and worm or endless screw (see fig. 21, Plate III.), in which the screw by revolving communicates a greatly reduced motion to the wheel. The three essential characters belonging to a screw-thread are its *pitch*, *depth*, and *form*; and the three principal conditions required in a screw when completed are *power*, *strength*, and *durability*. A square-threaded screw is the most powerful form. The durability of a screw-thread depends chiefly on its *depth*, or on the amount of bearing surface subjected to wear and the resistance of pressure. By the application of the screw in the form of a worm to a toothed wheel, Sir J. Whitworth has been able to divide the inch into 1,000,000 parts, each part being represented by a linear space of ·04 inch upon the rim of a graduated wheel. The introduction of a uniform system of angular screw-threads, now universally adopted, and called the *Whitworth thread*, is due to the same gentleman.

CHAPTER VIII.

COLLISION OF BODIES—ELASTICITY—FRICTION—PRINCIPLES OF WORK—ENERGY.

THE effects arising from the impact of a moving body on one which is either at rest or in motion, is termed the *collision* or *percussion* of bodies, and when the force acts for only a moment of time, and yet sensibly changes its velocity, it is an instantaneous or *impulsive* force. The effects of collision will depend upon the directions of the motions, with respect to a line joining the centre of gravity of the two bodies. All bodies in nature have certain degrees of softness or hardness: in the one case the particles yield to the force of impact, in the other they resist the effort to change their relative positions, and they have certain degrees of elasticity by which their particles, after being displaced, tend to recover their original position. This force of elasticity is very different in different bodies. Spheres of glass are those in which the force of restitution after impact approaches nearest to the force of compression, and in such spheres the ratio between the forces is as 15 to 16; in spheres of ivory the ratio is as 8 to 9, and in spheres of steel as 5 to 9. The absolute momentum, or quantity of motion in a body, is represented by the product of its mass and the velocity with which it is moving; but the effects of the collision of two bodies depend upon the law of the equality of action and reaction, or the relative velocities with which they approach or move from each other, so that whatever force the first body exerts upon the second, the second will exert an equal force upon the first in the opposite direction; this is the sum of the absolute velocities when the bodies, in approaching each other, move in opposite directions, and the difference when they move in the same direction. Let A and A′ (fig. 1, Plate V.), be two bodies moving with velocities V and U respectively in the same plane, in the direction of the line D B, passing through their centres of gravity C C′, and let their mutual action take place in that line, and let the motion of the one cause it to overtake the other, what will be their respective velocities at the instant after impact? If the bodies are *quite inelastic* when A touches A′ (fig. 2, Plate V.) it will continue to press against A′ until their velocities are equalized, when the mutual action ceases. For whatever deformation the bodies may have undergone, by reason of their inelasticity, they have no tendency to recover their original form.

Let x represent their common velocity after impact, then $Ax+A'x$ is their joint momentum at the end of the impact; but as their momentum before impact was $AV+A'U$, therefore $(A+A')x=AV+A'U$, an equation which determines the value of x. If the bodies are *perfectly elastic*, they recover their shape after impact, with a force exactly equal to that with which they were compressed, so that the momentum lost by the one and gained by the other is exactly double of that lost while compression took place, up to the instant at which their velocities were equalized. These are respectively $AV-Ax$ and $A'x-A'U$; therefore, if v and u are the required final velocities,

$$Av=AV-2\,(AV-Ax) \text{ or } v=-V+2x,$$
$$A'U=A'U+2\,(A'x-AU) \text{ or } U=2x-U.$$
$$\text{Therefore } (A+A')v=2A'U+(A-A')V,$$
$$\text{and } (A+A')u=2AV-(A-A')U.$$

The following deduction may be arrived at from these equations. Let the ball A moving with a velocity V, strike directly an equal ball A′ at rest, then $A=A'$ and $U=0$, consequently $V=0$ and $U=V$; that is, the former ball A is brought to rest, and the latter A′ moves on with a velocity V. If now A′ strikes a third equal ball A″ at rest, A′ will in turn be brought to rest, and A″ will acquire the velocity of V, and the same transference of velocity will take place if there is a fourth, or fifth, or any number of balls. This same result may be shown with glass or ivory balls, and illustrates in a very remarkable manner the mode of propagation of sound waves through the air. When two spheres strike each other in the direction of a line joining their centres of gravity, and there is no friction on the plane of their motion, a translation of the force of impact simply takes place without any *rotatory* motion. But if *friction* take place between the balls and the plane, then the former acquire a *rolling motion* on the latter; and to this circumstance is owing many of the phenomena observed in the game of billiards. Let the ball B (fig. 3, Plate V.) be impelled directly towards an immovable obstacle, such as the upright cushion at the edge of the table. Upon striking this cushion the ball will, generally speaking, recoil. Some substances will hardly give any recoil, while others will send back the ball with nearly the same velocity as that of its approach. At the moment of impact, the ball and the cushion compress one another, and the pressure continues until the reaction has destroyed all the velocity of the ball. If, then, there were no effort in the particles of the cushion, nor in those of the ball, to recover their former position, the ball would remain at rest close to the cushion. If the recoil were complete—that is, if the parts of both bodies endeavoured to recover their position with a force equal to that which disturbed them—the recoil would rapidly but gradually create in the ball a velocity equal to that with which it approached. In the first case the bodies are said to be entirely without elasticity, and in the second the elasticity of the bodies is said to be perfect. But if only a fr ction, e, of the velocity of approach be restored, then e is the measure of the elasticity of the bodies. Perfect elasticity is usually represented by unity. Now, suppose the ball B to approach towards the cushion L M, say in the direction D A. The line N O represents the line passing through the centre of gravity of the ball, and is drawn parallel to the line L M at a distance of half the diameter of the ball. Let B A be the velocity or length moved over in one second; then, the velocity B A is equivalent to the two velocities E A and B E. The first is destroyed and then partially restored by the impact; the second remains unaltered, except by the friction on the plane of the table at the moment of impact, which at present will not be considered. If, then, E D is taken equal to B E, E A will represent the perpendicular to L M, and its length such a fraction of E A as e is to 1; but as in the present case friction is not considered, it will be equal in length, the ball A will move, after impact, with the velocities E B and E D, that is, with the velocity A D in the direction A D. If the system were perfectly inelastic, the ball A would proceed along L M; if perfectly elastic, E A represents the perpendicular in both cases, and A D and A B are equally inclined to L M.

On the same principle may the motions resulting from the oblique impact of two elastic balls be determined. Therefore,

in two perfectly elastic balls of equal magnitude, the velocity of each after impact is that which the other had before the impact both in magnitude and direction, and the angle of incidence is equal to the angle of reflexion. In all cases perfectly elastic balls recede from each other after impact with the same velocity with which they approached before impact, since if $e=1$, $v-u=a-b$, in which a and b represent the velocities of the two balls A and B. But in every other case the rate of recess after impact is the same proportion of the rate of approach before impact which e is of 1. In all cases of impact, when the balls approach one another with uniform velocities, the common centre of gravity of the two balls moves uniformly and in a straight line. After impact, though the directions and velocity of the balls may have changed, their centre of gravity still continues to describe the same line, and with the same velocity as before.

If two bodies impelled forward with unequal velocities strike one another obliquely, then the direction of their motion after impact is determined by the following formula. Let the two bodies (fig. 4, Plate V.), B and D, move forward in the oblique directions B A, D A, and strike each other at A with velocities which are in proportion to the lines B A and D A; the direction of their motion after impact at A will be determined as follows:—Let L R M represent the plane in which the bodies touch in the point of impact, and draw the lines E N and E′N′ parallel to this plane, through the centre of gravity or half diameter of each body respectively. Draw the perpendiculars B E and D E′, and complete the rectangles E F, E′ F′. The motion in B A is therefore resolved into B E, E A; and the motion in D A is resolved into D E′, E′ A, of which B E, D E′, will represent the velocities with which they meet, and E A, E′ A, the distances they have travelled; and therefore the velocities with which the bodies meet are as B E and D E′, or their equals, F A and F′ A. The motions of the bodies B and D directly striking each other with the velocities F A and F′ A are readily determined, according as the bodies are elastic or non-elastic; therefore, let A P represent the ascertained velocity of one of them, B; and since there remains also in the body B a force of motion in the direction parallel to B F, with a velocity as B F, make A N equal to B F, and complete the rectangle P N; then the two motions in A N and A P are resolved into the diagonal A Q, which will represent the direction and velocity of the body B after impact at A. In the same manner the direction of the motion of the body D after impact at A, is determined, as represented by the diagonal A Q′.

FRICTION.

In considering so far the action of bodies in motion, either working on an axle, or where the parts are in contact with one another, the resistance offered to motion by *friction* has not been taken into account when two surfaces are moved upon one another. Whatever be the origin of friction, its effect is always that of neutralizing the action of mechanical force by transforming it into molecular motion. In some cases the resistance of friction becomes of great usefulness, and at other times it forms an element of considerable waste. Were it not for the resistance of friction a nail or a screw would have no holding power, and cease to be of value; and without friction a railway train could not be set in motion; but in machinery, where the several parts are either revolving or rolling, and rubbing surfaces come into play, then friction becomes a direct loss of power. The surfaces of bodies in contact are never perfectly smooth, that is, true planes; and even the smoothest surfaces, though apparently so both to the touch and sight, present inequalities, so that when one surface moves over another the elevations of the one fall into the depressions of the other, and thus offer a certain resistance to motion which continually acts as an opposing force to actual or possible motion. It can check or destroy, but it cannot generate motion, and the tendency of friction is always to promote repose and insure stability.

Friction is of two kinds: *sliding*, as when one surface moves over another; and *rolling* friction, as when one body rolls over another. Rolling friction being considerably less than sliding friction, a great saving of power is effected when the latter is converted into the former. Examples of this occur in the application of casters to articles of furniture and the roller skate, the sliding friction over the floor being changed into a rolling friction. On the other hand, advantage is often gained by converting a rolling into a sliding friction. This is forcibly illustrated in the action of the railway break on the tyre of the wheel in a railway carriage, by which the motion of the carriage is speedily arrested. The friction on the ground enables a man and a horse to move, and without friction it would be difficult even to hold anything in the hands; the resistance of friction again is utilized as a means for the transmission of power from one wheel to another by the employment of bands, straps, or ropes.

The laws relating to friction are generally stated as follows:—

1. *The friction between two surfaces of the same kind is in direct proportion to the pressure between them.* Thus, if a block of any substance be double the weight of another, and both, having equal surfaces of contact, are placed on one plane of a uniform nature, the force required to move the first will be double that which is needed to move the second.

2. *The amount of friction is independent of the extent of the surfaces in contact.* For instance, if a block of 60 lbs. weight can only be moved by a force equal to, say, 25 lbs., it will require a force of 50 lbs. to move *two* blocks, each of the same weight, placed *side by side;* but place the blocks one upon the top of the other, the 120 lbs. will still require an identical amount of force, 50 lbs., to move them.

3. *The friction is independent of the velocity when the body is in motion.* The amount of friction between two bodies will depend very much on the substances of which these bodies are composed. Thus, between oak and cast iron, it is about ·38; for wrought iron on wrought iron, the amount is represented by ·44; for brass acting upon cast iron, ·22—the surfaces being dry and horizontal in every case. This fraction, which is that proportion of the pressure between two surfaces required to overcome their friction, is called the *coefficient of friction.* The following table gives the comparative friction of different metals under an average weight or pressure of from 54·25 lbs. to 69·55 lbs.:—

Name of Metals.	Average Load in Lbs.		Proportion of Load to Friction.
Brass upon wrought iron, . . .	69·55	...	7·312
Brass upon cast iron, ...	54·25	...	6·745
Brass upon steel, ...	69·55	...	6·592
Hard brass upon cast iron, . .	54·25	...	6·581
Brass upon brass, ...	69·55	...	6·764
Steel upon steel.	69·55	...	6·860
Wrought iron upon wrought iron,	69·55	...	6·561
Cast iron upon cast iron. . . .	54·25	...	6·475
Cast iron upon wrought iron, .	69·55	...	6·023
Cast iron upon steel, ...	69·55	...	6·393
Tin upon tin, ...	69·55	...	3·305

It appears, therefore, from these data that the friction between hard metals is less than that between soft, and that the friction of hard against hard may, as a general rule, be computed at about one-sixth of the pressure, or ·17.

To diminish the resisting energy of friction grease or unguents are commonly employed. When gun-metal is loaded with weights varying from 1 to 2 cwts. the friction varies nearly in the proportion of 1·7 to 1·4 of the pressure, and is scarcely affected by time; with brass it increases, and diminishes when cast iron is tried; and the decrease is still greater when blacklead is interposed between the three different metals. If oil be employed for gun-metal or cast iron, with a weight of 2 cwts., the friction will amount to only $\frac{1}{583}$ of the pressure. Diminish the pressure and the friction is reduced to $\frac{1}{3733}$; cast iron, under similar conditions, showed less friction; this was also again diminished by the application of hog's lard. The coefficient of wrought iron upon dry oak is ·49. Use water and it is reduced to ·26; dry soap, and it is diminished to ·21. The general rule derived from experiment is that, with the unguents, hog's lard and olive oil, interposed in a stratum between the surfaces of wood on metal, wood on wood, metal on metal, when

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ELASTICITY & TENACITY—HYDRODYNAMICS.

Fig. 1.

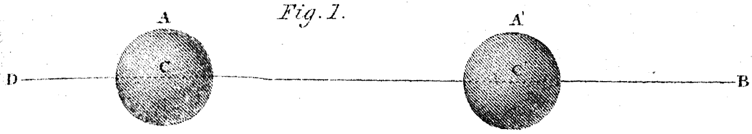


Fig. 2.

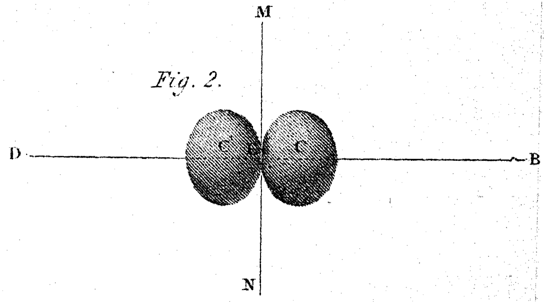


Fig. 3.

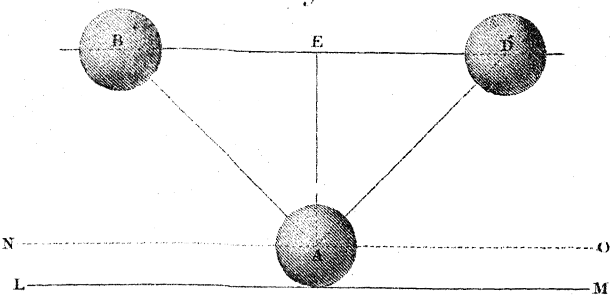


Fig. 4.

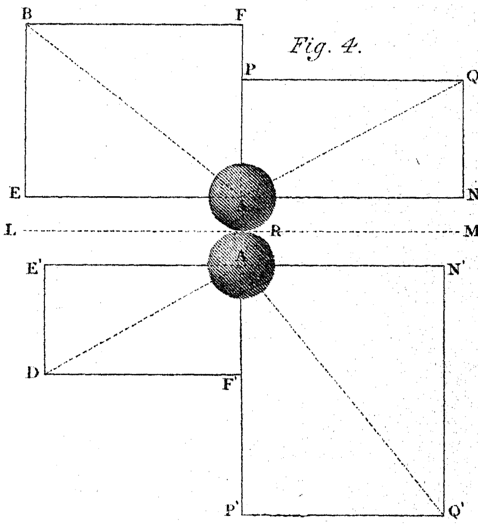


Fig. 5.

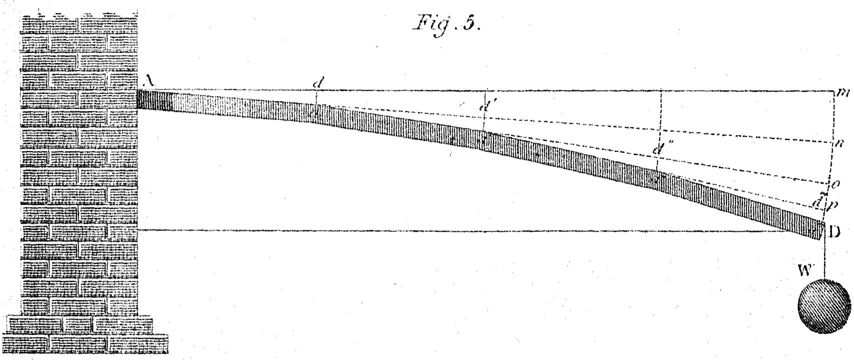


Fig. 6.

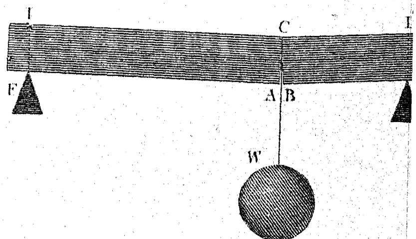


Fig. 8.

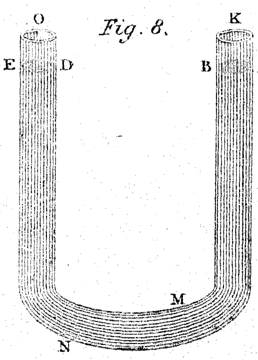


Fig. 9.

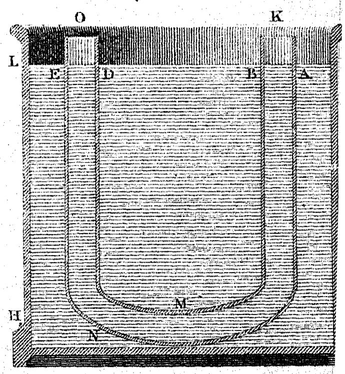
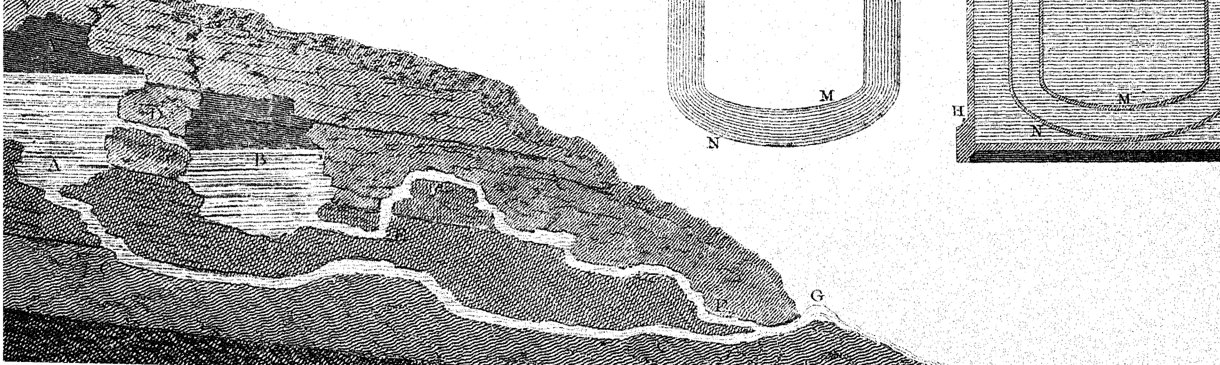


Fig. 7.



in motion, they all give very nearly the same coefficient of friction—the value of that coefficient being included between ·07 and ·08. Tallow gives the same coefficient as oil, except when metals are brought to bear upon metals; it then rises to ·10. With all *porous* substances friction is increased by time and surface, and *diminished* by time and velocity. With woods, metals, and stone the amount of friction is simply in proportion to the pressure, and is unaffected by time, surface, or velocity.

The annexed table, founded on Morin's experiments, shows the coefficient of friction of certain plane surfaces after they had been for a short time in contact:—

Name of Surfaces.	Condition of Surfaces.	Disposition of the Fibres.	Coefficient of Friction.
Oak upon oak, . .	Dry. ...	Parallel. ...	·60
Oak upon oak, . .	" ...	Perpendicular. ...	·54
Oak upon oak, . .	Wet. ...	" ...	·71
Elm upon oak, . .	Dry. ...	Parallel. ...	·69
Elm upon oak, . .	" ...	Perpendicular. ...	·57
Ash upon oak, . .	" ...	Parallel. ...	·50
Fir upon oak, . .	" ...	Perpendicular. ...	·52
Beech upon oak, .	" ...	Parallel. ...	·53
Wrought iron upon oak, ...	" ...	" ...	·62
Brass upon oak, .	" ...	" ...	·62
Copper upon oak, .	" ...	" ...	·74
Hemp cord upon oak, ...	" ...	" ...	·64
Oak upon cast iron,	" ...	" ...	·38
Wrought iron upon wrought iron, .	" ...	" ...	·44
Brass upon cast iron,	" ...	" ...	·22

The *coefficient of friction* is denoted by the Greek letter μ, so that, if R be the perpendicular pressure between two surfaces, and F the friction, then the ratio of F to R is a constant number, when the surfaces are of the same material and in the same condition; that is, $\frac{F}{R} = \mu$ and $F = \mu R$. The *angle of repose* is the angle at which any plane may be inclined to the horizon before a body placed on it will begin to slide down. The forces acting are the *friction* F, the *weight* W, acting vertically, and the *reaction* or perpendicular pressure between the two surfaces, R, the angle of inclination of the plane being a, then $F = R \tan a$; but as $F = \mu R$, then $\mu = \tan a$.

Sir J. Anderson gives an illustration of friction in the case of a traction engine employed to drag a heavy load up an incline. On a level road, with the weight of engine 12 tons; net weight of train, 48 tons; coefficient of traction, 150 lbs. per ton; the tractive power of the engine is $(12+48)$ 150, or 9000 lbs. On an incline of 1 in 10, the tractive power of engine to balance gravity is $\frac{2240}{10} = 224$ lbs. per ton; coefficient of traction, 150 lbs. per ton; total tractive power required, 374 lbs. per ton; gross weight of train, $\frac{9000}{374} = 24$ tons; net weight of train $(24-12) = 12$ tons. Therefore the tractive force on a level road being taken at 150 lbs. per ton, and it being assumed that the engine is capable of dragging a train of 48 tons along this road, the total tractive power of the engine is equal to 9000 lbs. When, however, the weight is resting on an incline the tractive force differs but slightly, because the pressure on the plane is only a little less than the actual weight. The total tractive force, however, is now increased by the additional force necessary to prevent the train running down the incline of 1 in 10, which is 224 lbs. per ton, and the result is, that the engine is only able to draw 12 tons up the incline as against 48 tons along a level road.

RESISTANCE OF FRICTION.

When a cylinder rolls on a horizontal plane the resistance of friction speedily brings it to rest; the amount of resistance from rolling friction is much less than that due to sliding surfaces, and it is from this circumstance that the value of friction rollers and friction wheels results. *Friction wheels* consist of two pairs of large but comparatively light wheels set close together in pairs and parallel, in such a manner that the circumference of one partially laps over that of the other, and in the angles thus formed by the upper circumference of the two pairs of wheels the chief axle is placed, so that the friction is removed from the axle to the *axles of the wheels*, and reduced in the proportion of the diameter of the friction wheels to that of the chief axle. The tractive force necessary for pulling a train along a level line is affected by the friction of the axles, and the friction of the wheels themselves against the rails; also by the resistance of the air, by the direction of the wind, and by the nature of the curves on which the wheels run. It is usually assumed that the force required to start a carriage, with grease axle-boxes, lies between 11 lbs. and 18 lbs. per ton. With oil axle-boxes the tractive force necessary is from 12 lbs. to 22 lbs. per ton of load, and the force necessary to keep the carriage in slow motion varies from 2 to 5 lbs. per ton of load. The destruction of power when a cord is wound round a cylinder shows how a multitude of very minute forces are increased by accumulation; it is upon this principle that the retardation of velocity in ships and steamboats is effected on being moored to piers, or the momentum of a falling anchor is reduced. On the rope being coiled round the post or capstan, the friction exerted by each portion of the rope is accumulated so as to produce the final resistance; and thus, with one coil round the post or cylinder, the weights which balance when hung on the two ends of the rope will be in the proportion of about 1 to 9; with two coils the ratio will be about 1 to 81, and so on as the number of coils is increased. From the result of a series of practical experiments on the action of friction-brakes upon wheels and railway trains, it appears that the efficiency of a brake depends on the rapidity with which the pressure can be put on the brake, and on the amount of the pressure being properly proportioned to the speed of the train and the *adhesion* of the wheels. It is the adhesion between the wheel and the rail which gives rise to the rolling motion, and as the point of the wheel in contact with the rail is for the moment at rest, the adhesion is that bordering on motion, and its value may be regarded on an average at ·24 or ·25 of the weight.

The attraction exerted between the molecules of bodies when their surfaces are brought into close contact is termed *adhesion*. In some cases adhesion differs but slightly from cohesion, as when two surfaces of lead are pressed together, it acts at insensible distances like that force. Adhesion takes place between solids; for instance, when two equal pieces of polished glass with a plane surface are pressed together the force of adhesion is so strong that the glass breaks without being separated, and as this adhesion takes place *in vacuo* it does not arise from atmospheric pressure, but is the result of a reciprocal action between the two surfaces; the force of adhesion is increased as the contact is prolonged, and becomes greater in proportion as the contact is closer. The action of glue in uniting two plane surfaces of wood is owing to this property; the two surfaces of the wood are rubbed together until the glue is nearly expelled, and their surfaces are brought into the closest possible proximity, the glue being only a liquid medium to fill up the inequalities of the pores and crevices on the surfaces. The force of adhesion here is so great that frequently the mass breaks more readily at other places than at the parts joined by adhesion. In the same way two freshly cut surfaces of india-rubber, when pressed together, adhere with great tenacity, and ultimately form one compact solid mass. Adhesion takes place between liquids and solids, and with a more powerful force than between solids. A glass rod, dipped into water, on being withdrawn will have a drop collected at its lower extremity, which will remain suspended there, and as gravity tends to detach it the superior force of adhesion maintains it there. A further illustration of the force of adhesion is the collecting of dust on walls, writing and drawing with chalk and pencils, which entirely depend on the adhesion of solids. The same in writing with inks; the liquid penetrates into the pores of the substance, carrying the particles of solid matter with it; as the liquid evaporates the particles remain by the force of adhesion. Tables have been prepared showing the resistance

of adhesion of different kinds of nails when driven into dry deal. A sixpenny nail, seventy-three to the pound, and $2\frac{1}{2}$ inches long, forced $2\frac{1}{2}$ inches into dry deal, required 327 lbs. weight to extract it; the percussive force required to drive the nail to a depth of $1\frac{1}{2}$ inches with a cast-iron weight of 6·275 lbs., was four blows or strokes falling freely the space of 12 inches, and the steady pressure to produce the same effect was 400 lbs. When the nail was driven $2\frac{1}{2}$ inches into dry oak, it required a force of over 1112 lbs. to extract it by pressure.

It has already been noticed that when the form of a body is affected by the pressure of another extraneous to it, the reacting force by which it sustains or tends to remove that pressure is its elasticity. The cause of elasticity belongs to the theory of molecularity, its effects in aggregate masses to mechanics. Elasticity in solids is called into action by traction, torsion, and by flexure. Bodies are said to be highly elastic which, like india-rubber, undergo a considerable change on the application of a very small force; still the force of elasticity is often greater in many bodies, such as iron, which do not appear very elastic. Those bodies which by the exertion of a small force undergo a considerable change of form have also generally the property of undergoing this change without losing the tendency of the particles to return again to their original state. And those bodies which require a considerable force to effect a change are mostly those in which the force produces some permanent change and do not recover their form altogether when the force is no longer exerted. The experiments of Savart demonstrate that for elasticity of traction or pressure, *the alteration in length, within the limits of elasticity, is in proportion to the length and to the load acting on the body, and is inversely as the section.* It depends, however, on the *specific elasticity;* that is, on the material composing the body.

If this coefficient be represented by E, and if the length, section, and load are respectively designated by l, s, and P, then for the alteration in length, e, there will be $e = \mathrm{E}\,\frac{l\,\mathrm{P}}{s}$.

The following are the elasticities of some of the principal substances.

Steel,	21·000	Plate glass,	7·015
Wrought iron,	19·000	Marble,	2·609
Platinum,	17·044	Lead,	1·800
Copper,	12·400	Bone,	1·635
Slate,	11·035	Wood,	1·100
Brass,	9·000	Whalebone,	·700
Zinc,	8·700	Sandstone,	·631
Silver,	7·400	Ice,	·236

The weight which, when applied to a body of unit section, is just enough to cause an appreciable permanent change, is a measure of the limit of elasticity of that body. The elastic force of a twisted string follows a law precisely similar to that of one which is only stretched; the latter is proportional to the extension, the former to the torsion. If a cylindrical elastic thread, fixed at one end, be twisted by a force applied perpendicularly to its length, any straight line taken along the surface of the cylinder will be converted into a helix, and with a double torsion the circular arc through which each point has been removed from its original place is doubled. And as the circular arc may be subdivided into any number of equal arcs, the successive resistances of the elasticity to the additional torsions are equal, supposing each preceding resistance to be sustained. Therefore, the accumulated force of torsion is proportional to the angle through which an index would move if fixed at any point perpendicularly to the length of the cylinder, or in the prolongation of its radius; but this law has limits as well as that for the elasticity of tension, for the torsion may be continued until a strain is produced, when there will be an accompanying diminution of elastic force. The laws of the torsion of wires were determined by Coulomb, who devised an instrument called the *torsion balance.* It consists of a metal wire suspended at one end to a frame, and supporting at the other end a metal ball, to which is attached an index. Immediately below the index is a graduated circle. If the index is turned from its position of equilibrium through any angle, which is then the *angle of torsion,* the force necessary to produce this effect is the *force of torsion.* When, after this deflection the ball is left to itself, the reaction of torsion ensues, and the wire untwists itself, the ball rotating about its vertical axis with increasing rapidity until it finally reaches its position of equilibrium. It does not, however, rest there; for by its inertia it passes this position, and the wire undergoes a torsion in the opposite direction. The equilibrium being again destroyed, the wire again untwists itself, the same alterations are again produced, and the index does not rest at the zero of the scale until after a certain number of oscillations about this point have been completed. By means of this torsion balance Coulomb found that when the amplitude of the oscillations is within certain limits, the oscillations are subject to the following laws:—*The oscillations are very nearly isochronous.* For the same wire, *the angle of torsion is proportional to the moment of the force of torsion.* With the same force of torsion, and with wires of the same diameter, *the angles of torsion are proportional to the lengths of the wires.* The same force of torsion being applied to wires of the same length, *the angles of torsion are inversely proportional to the fourth powers of the diameters.* The laws of torsion may be deduced from the formula $w = \frac{1}{\mathrm{T}}\,\frac{\mathrm{F}\,l}{r^4}$, in which w is the angle of torsion, F the moment of the force of torsion, l the length of the wire, r its diameter, and $\frac{1}{\mathrm{T}}$ the specific torsion coefficient.

When a solid is cut into a thin plate or bar, and fixed at one end, after having been more or less bent, it strives to recover its original position when left to itself. This property, the *elasticity of flexure,* is very well defined in steel, india-rubber, wood, and some other substances. A D is a rectangular bar (fig. 5, Plate V.), fixed into a wall at A, and loaded at the end D by the weight W. The line Am is its normal position before loading. The flexure e of the bar is represented by the following formula: $e = \frac{\mathrm{W}\,l^3}{b h^2 \mu}$, in which W is the load, l the length of the bar, b its breadth, h its thickness, and μ the modulus or coefficient of elasticity. The length of the bar A D being divided into four equal parts, $d\,a$, $d'a'$, $d''\,a''$, $d'''a'''$, become respectively the sines of the angles $m\mathrm{A}n$, $n\,a\,o$, $o\,a'p$, $p\,a''a'''$.

The elasticity of flexure is applied in a great number of instances, as in carriage-springs, watch-springs, bows, and the springs employed for mattresses, cushions, buffer springs, safety valves, &c. When a weight or force acts on any part of a horizontal beam supported at both ends, the pressure on that part is as the rectangle or product of its two distances from the supported ends; therefore, the stress upon the beam I I′ (fig. 6, Plate V.), supported at the two ends F F′ by the weight W placed at C, is as $\mathrm{FA} \times \mathrm{BF}'$, because, by the principle of the lever, the effect of the weight W on the lever F A is $\mathrm{FA}.\mathrm{W}$; and the effect of this force acting at C, on the lever B F′, is $\mathrm{FA}.\mathrm{W}.\mathrm{BF}' = \mathrm{FA}.\mathrm{BF}'.\mathrm{W}$. The weight W being known, the effect of the pressure or stress is as F A. The greatest strain on the beam is when the weight W is at the middle, for then the rectangle of the two halves $\mathrm{FA}.\mathrm{FA} = \frac{1}{2}\mathrm{FF}'.\frac{1}{2}\mathrm{FF}' = \frac{1}{4}\mathrm{FF}'^2$, which is the greatest. As the pressure is moved from the middle point, the stress becomes less and less as it approaches the extremities, where it is nothing. Again, if w is the greatest weight that a beam can sustain at its middle point, the position on the beam where it will support any greater weight W will be found by the following proportions, $\mathrm{W} : w :: \frac{1}{2}\mathrm{FF}'.\frac{1}{2}\mathrm{FF}'$, or $\frac{1}{4}\mathrm{FF}'^2 : \mathrm{FA}'.\mathrm{BF}'$, or $\mathrm{FA} \times (\mathrm{FF}' - \mathrm{FA}) = \mathrm{FF}'.\mathrm{FA} - \mathrm{FA}^2$.

The ultimate strength or breaking load of a bar exposed to direct and uniform tension *is the product of the area of cross section of the bar into the tenacity of the material.* If P denote the breaking load in pounds, s the area of section in square inches, f the tenacity in pounds on the square inch, then $\mathrm{P} = f s$, $s = \frac{\mathrm{P}}{f}$. Tenacity diminishes with the duration of the strain. A small force continuously applied for a long time will frequently break a wire which would not at once be broken by a heavier weight. Tenacity, like elasticity, is different in different directions in bodies. In wood both the tenacity and the elasticity are greater in the direction of the

fibres than in a transverse direction, and this difference is maintained to a certain extent in all bodies the texture of which is not the same in all directions. The following are some of the most useful values of the tenacity of materials in pounds on the square inch.

Bronze or gun-metal (copper 8, tin 1),	36·000
Copper, cast,	19·000
" sheet,	30·000
" bolts,	36·000
" wire,	60·000
Iron, cast, various qualities,	13·400 to 29·000
Cast iron, average British,	about 16·500
Iron, malleable, boiler plates,	50·000
" " large forgings,	40·000 to 50·000
" " bars, rods, and bolts,	50·000 to 70·000
" " wire,	70·000 to 100·000
Steel,	80·000 to 130·000
Ash,	17·000
Fir and pine,	12·000 to 14·000
Oak,	10·000 to 19·800
Teak, Indian,	15·000
Hempen hawser, *girth in inches squared,*	× 1·050
Hempen cable, *girth in inches squared,*	× 672
Iron wire ropes, *per square inch of iron,*	90·000
" " *per pound weight to fathom,*	4·480
Leathern belts, *working tension per square inch,*	285
Silk fibre, *tenacity per square inch section,*	52·200

The tenacity of cylindrical boilers and pipes may be determined if r denote the radius of a thin hollow cylinder, such as the shell of a high-pressure boiler, t the thickness of the shell, f the tenacity of the material in pounds per square inch, and p the intensity of the pressure in pounds per square inch required to burst the shell. This pressure ought to be taken at *six times* the effective working pressure—*effective pressure* meaning the excess of the pressure from within above the pressure from without, which last is usually the atmospheric pressure of 14·7 pounds on the square inch, or thereabouts. Then $p = \frac{ft}{2}$; and the proper proportion of thickness to radius will be given by the formula $\frac{t}{2} = \frac{p}{f}$. Tenacity varies greatly with the form of a body. With the same sectional area, a cylinder has greater tenacity than a prism. The quantity of matter being the same, a hollow cylinder has greater tenacity than a solid one; and the tenacity of this hollow cylinder is greatest when the external radius is to the internal radius in the ratio of 11 to 5. The shape has also the same influence on the resistance to crushing as it has on the resistance to traction. A hollow cylinder with the same mass and the same weight, offers a greater resistance than a solid cylinder. Thus it is that the bones of animals, the feathers of birds, the stems of corn and other plants, are stronger than if they were solid, the mass remaining the same.

The *limit of elasticity* of wrought iron is about 10 tons to the square inch, and the lengthening effect on a bar by each ton of strain is $\frac{1}{10000}$ part. When the limit of elasticity in a body has been exceeded, a new property comes into play, namely, *ductility*. If cylindrical bars of iron or steel be placed in a testing machine, and force is exerted until the bars are pulled asunder, it will be found upon examination, when the two pieces of a bar are fitted together, that the bar has been elongated throughout, but mostly near the centre where it has broken. If the length of the bar was 4 inches before the strain was applied, and after fracture is found to be 5 inches long, then the ductility is said to be 25 per cent. Sir J. Whitworth estimates the tensile strength or breaking strain for a square inch bar of Lowmoor iron at about 27 tons, with a ductility of 38 per cent. It is this property of ductility in metals which admits of their being drawn out in length as wire, while the diameter only is diminished without any actual fracture. The most ductile of the metals are in the following order:—Gold, silver, platinum, iron, copper, zinc, tin, lead, nickel. Platinum is so ductile that 1·25 of a grain is capable of being drawn into a wire 0·00003 of an inch in diameter and a mile in length.

Malleability is only a modified form of ductility, and a metal is said to be malleable when it can undergo hammering without exhibiting signs of fracture. Gold is the most malleable of all the metals, and is capable of being beaten out into sheets or leaves about the $\frac{1}{300000}$ of an inch in thickness.

As all bodies vary in their density, so the property of *hardness*, or the resistance which bodies offer to being worn away or scratched by others, is only a relative expression, and has no relation to the resistance of the body to compression. Glass is much harder than wood, but the blow of a hammer which would fracture glass is resisted by wood. A body may be hard in reference to one body and soft in reference to others. The relative hardness of two bodies is determined by trying which of them will scratch the other. The diamond is the hardest of all substances, for while it will scratch all others it is not scratched by any. Bodies have been classified into a *scale of hardness:*—

1. Talc.	5. Apatite.	8. Topaz.
2. Rock salt.	6. Felspar.	9. Corundum.
3. Calcspar.	7. Quartz.	10. Diamond.
4. Fluorspar.		

Thus the hardness of a body which would scratch topaz, but would be scratched by corundum, would be expressed by the number 8·5. The pure metals are softer than their alloys, and for that reason coinage and jewelry of gold and silver are alloyed with copper to increase their hardness and resistance to the wear and tear of friction. If a soft body moves with great velocity, it is then capable of cutting into a hard body. A disc of soft iron revolving with rapid speed will cut through a hard steel file, and if the velocity of rotation is sufficient will even cut into agate and quartz. Many bodies, after they have been raised to a high temperature, acquire great hardness by sudden cooling. This operation is termed *tempering*. The value of all cutting instruments and coiled springs depends upon the perfection of their tempering. A badly tempered chisel or knife soon gives way on the cutting edge if the tempering is too hard, and also speedily loses its sharpness if the tempering is too soft. Steel is usually tempered by being immersed at a bright cherry-red heat in a bath of oil, at a temperature varying from 430 degrees to 600 degrees. The more sudden the cooling, the greater is the hardness produced.

PRINCIPLES OF WORK.

It has already been shown under "Newton's laws of motion" that a body, whether at rest or in motion, must continue at rest or in motion in the same direction and with the same velocity, unless some *external force* is brought into action to change either the direction or velocity of its motion. But the action of a force may be otherwise shown. Thus a ship under sail continues its motion quite uniformly under a uniform pressure of wind. Yet the wind is performing work because it is occupied in counteracting those forces, such as the friction of the water, which tend constantly to destroy the motion of the vessel and bring it to a state of rest.

Thus there are two classes of cases both of which indicate the expenditure of force:—

1. Where the velocity of motion of any body is continually altered, as in the case of a body falling freely in space under the influence of gravitation.

2. Where the motion of any body is *maintained* in opposition to forces tending to resist its motion.

In each of these cases *work* is said to be performed, and to measure the force thus expended a *unit of work* has been adopted. The simplest case is where the resistance is constant and the direction of motion is opposite to the direction of the resistance. This would occur when a weight suspended on a rope is lifted by a force acting through the rope. The *work done* is then measured by the product of the number of pounds lifted into the number of feet through

which they are raised; the product is the number of *foot-pounds;* thus, if 25 lbs. be raised 6 feet, the work done is 150 foot-pounds. The *unit of work* is the work done in raising 1 lb. 1 foot high, and is called a *foot-pound.* The French unit of work is one kilogramme raised one mètre, and is termed a *kilogrammètre.* Its value is 7·2331, or about $7\frac{1}{4}$ foot-pounds. The term *power* is applied to the *rate of doing work.* The sustained work of a horse continued for one minute is estimated to raise 33,000 lbs. 1 foot, or 33,000 foot-pounds represent the rate of work of a horse per minute. This is the value of what is technically termed a *horse power.* The rate at which a man does work per minute is taken at the value of 3300 foot-pounds, or $\frac{1}{10}$ that of a horse.

The *principle of work* contains the whole theory of equilibrium, and in order that work may be done, some one or more of the forces employed must preponderate. The condition of the equality of moments in a lever follows directly from the principle of work. The principle of work embraces a truth which has passed into a common saying, namely, "What is gained in power is lost in time." To gain in power means that it is possible to move a heavy weight by a small force, and to lose in time means that it can only be accomplished very slowly. The work done by a force is usually represented by a diagram, as work done by a constant force is the product of the force into the space moved through by its point of application in the direction of the force; and as force and space are both represented by straight lines, work done is represented by an area. There is another mode of estimating work derived from the laws of motion. When force acts upon a free body it will set it in motion, the inertia of the body representing the resistance to be overcome by the force; and therefore work is done in impressing velocity upon a body. In the same way a body in motion can only be brought to a state of repose by the expenditure of force, and work is therefore done during the destruction of the motion. When a body is raised to a certain height, and then allowed to fall, it acquires in falling a velocity dependent on the height through which it had been raised. If it were possible to suddenly reverse its motion, the body would rise to the exact height from which it fell, and in so doing would perform work. Therefore the velocity acquired in falling is a measure of the work done in lifting the body, and is produced by the action of a definite force, the weight of the body acting through a definite space, namely, the height through which the body has been raised; so that it may be said that work is stored up in a body in motion, and the measure of the work is the height through which the body must be raised, in order that by falling it may acquire the velocity with which it is actually moving. The velocity hitherto under notice has been linear velocity, but it is evident that where more than one force is in action in different directions, the body acted on may describe a curve. The *inertia* due to mass is always present, and work can equally well be stored up in a rotating wheel as in the head of a steam hammer. Therefore the heavy rotating fly-wheel of an engine becomes a reservoir in which the work of the engine can be accumulated. To estimate the work stored up in a body rotating with a given velocity, let the body of a weight, w, move in a circle of radius, r, with a lineal velocity of v. A line drawn from the body to the centre of the circle will move round the centre with an angular velocity, represented by w. Then $v = w\,r$. But the work stored up in the body is—

$$\frac{\mathrm{W}v^2}{2g} = \frac{\mathrm{W}w^2r^2}{2g} = \frac{\mathrm{W}^2}{2}\,(\text{mass}) \times (\text{radius})^2.$$

From this expression it appears that the work stored up in the separate parts of a body moving with a given angular velocity depends upon the *square of the distance* of each part from the axis; and a pound weight at a distance of 4 feet from the axis of rotation has sixteen times as much work stored up in it as the same weight at a distance of 1 foot from the axis, the angular velocity of rotation being the same in both cases.

The term *energy* in mechanics has only one meaning, namely, the *capacity for performing work.*

ARITHMETIC.—CHAPTER IV.

DIVISION OF WHOLE NUMBERS.

Division is the process of ascertaining how many times (or parts of times) one number is contained in another. It is therefore, in reality, a concise method of performing many subtractions of the same number, and is, as an operation, exactly the inverse of multiplication. In multiplication the product of two numbers consists of one of these numbers repeated as many times as the other contains 1, that is to say, the product contains one of the factors the number of times expressed by the other. If, therefore, we have a product given and one of the factors, the other factor will be found by reversing the process by which the product was formed—that is, by subtracting the known factor continually from the product until nothing is left. Thus, supposing it is required to find how often 161 contains 23, or that the following question is asked:—There is a heap containing 161 pebbles, how many less heaps, containing each 23 pebbles, can be formed out of it? The simplest mode of proceeding is obviously to take 23 from the great heap, and put them into a new heap by themselves; then to take another 23 from it, and place them in another heap by themselves; and so on until the original heap is exhausted. After *seven* subtractions we find that nothing is left, and therefore we conclude that 161 contains 23 that number of times. Here 161 is called the *dividend*, 23 the *divisor*, and 7 the *quotient.* The arithmetical process by which a quotient is found is *division.*

161	
23	1
138	
23	1
115	
23	1
92	
23	1
69	
23	1
46	
23	1
23	
23	1
0	7

When the divisor is not greater than 12 a knowledge of the multiplication table enables us to abridge these processes. To show how this is accomplished, let it be required to divide 38024 by 7. The operation is here shown both at full length and in the abridged form.

It is easy to recollect—without being at the trouble of writing it down—that 38 divided by 7 gives a remainder, 3; this 3, placed before the next figure of the dividend *mentally*, makes 30, which, divided by 7, gives a remainder, 2; this 2, again, placed before the 2 of the dividend makes 22, which, divided by 7, gives a remainder 1; this placed before 4, the last figure of the dividend, makes 14, which, divided by 7, gives a remainder 0.

Common Process.

```
7)38024(5432
  35
  —
   30
   28
   —
    22
    21
    —
     14
     14
     —
      0
```

Abridged Process.

```
7)38024
   5432
```

This method is likewise applicable when the divisor can be resolved into two or more factors not exceeding 12. For as in multiplication we may multiply successively by the factors of the multiplier (page 218), so in division we may reverse the process and divide a dividend successively by the factors of a divisor (the dividend being regarded as a product obtained by multiplying the quotient by all the parts of the divisor).

Thus $7964 \times 48 = 7964 \times 6 = 47784 \times 8 = 382272.$

Therefore $382272 \div 48 = 382272 \div 8 = 47784 \div 6 = 7964.$

The method of applying this principle is shown in the following examples, in which it will be observed that the order of the factors is unimportant.

Divide 709695 by $63 = 7 \times 9$		Divide 1573056 by $44 = 11 \times 4$	
Processes.		Processes.	
9)709695	7)709695	4)1573056	11)1573056
7) 78855	9)101385	11) 393264	4) 143005—1
11265	11265	35751—3	35751—1

In the last example there is a difficulty in the case of the remainder. By the first process we obtain 3 over at the final division, and by the second we get 1 at each division. But if we try the question by the common method we find that the true remainder is 12; we must, therefore, determine some method of getting this number from the partial remainders

obtained. Now $4 \times 3 = 12$, and $1 \times 11 + 1 = 12$; that is, (1) the *last* partial remainder multiplied into the *first* partial divisor gives the true remainder when there is no previous partial remainder; but (2) when there is a preceding remainder it must be added to the product. This rule must, in the meantime, be accepted as true, but the reason of it will soon be made perfectly obvious.

When the dividend contains the divisor a great number of times, it is hardly practicable to employ continued subtraction to obtain the quotient; and, accordingly, we have recourse to methods of abbreviation analogous to those employed in multiplication. But before proceeding to explain these, it is necessary to observe that when the divisor is not greater than 12, and the dividend not more than 12 times as great as the divisor, the quotient must be contained among the products of the multiplication table given in page 216. For example, if it be inquired how often 56 contains 8, on consulting the table we find 8 in the column of multipliers, and 56 in the same horizontal line and under 7; the other factor, 7, expresses therefore the number of times which 56 contains 8. But this table, as was shown on page 216, does not contain among its products all numbers between 4 and 144, although it contains all the factors between 2 and 12; there must, therefore, be numbers within that range which cannot be divided exactly by any of these factors. We find, for instance, in the table 42 and 44, but not 43. This number is therefore not divisible exactly by any factor given in the table; but further, we observe that 42, although it occurs twice, is not found among the products of 8, and we therefore conclude that it is not divisible exactly by 8. This may be proved by following the process explained above. It will at once appear that, having subtracted 8 five times from 42, there remains 2; we then say that 42 contains 8 five times and 2 *over*, or that 42 divided by 8 gives as *quotient* 5 and a *remainder* of 2. This is exactly what the table informs us; for as 42 is between 40 and 48, we observe that the highest product of 8 which it can contain is 40, the factors of which are 8 and 5, and the difference between 42 and 40 is the remainder 2. If we use signs the expression would stand thus:—

$$42 = 8 \times 5 + 2, \text{ or } 42 \div 8 = 5\tfrac{1}{4}.$$

The sign used to denote arithmetical division is sometimes $\div$, and at other times (:), but by far the neatest and most convenient way of expressing division is to write the dividend above, and the divisor beneath a small horizontal line. These modes are exemplified in the division of 8 by 4 thus:—

$$8 \div 4 = 2, \qquad 8 : 4 = 2, \qquad \frac{8}{4} = 2.$$

For convenience' sake we sometimes arrange the figures as follows:—

When the divisor is small, $\dfrac{4)8}{2}$; when large, 43)903(21

We have seen that in dividing one number by another, we may break up the dividend, and divide each of its parts by the divisor, and then add the results together. Thus, it is plain that 144 contains 8 just as often as all its parts together. Now 144 is made up of 80, 40, and 24, and of these

80 contains 8 10 times,
40 contains 8 5 times,
24 contains 8 3 times.

Therefore $80 + 40 + 24$, *i.e.* 144, contains 8 $10 + 5 + 3$ times, *i.e.* 18 times.

But again, 144 is made up of 100, 40, and 4;

and 100 contains 8 12 times and 4 over (or $12\frac{1}{2}$),
40 contains 8 5 times and 0 over (or 5),
4 contains 8 0 times* and 4 over (or $\frac{1}{2}$).

Therefore $100 + 40 + 4$ contains 8 $12 + 5 + 0$ times and $4 + 0 + 4$ over, or 144 contains 8 17 times and 8 over. But 8 contains 8 1 time, and therefore 144 contains 17 eights and 1 eight, *i.e.* 18 eights (or $12\frac{1}{2} + 5 + \frac{1}{2} = 18$ times).

The proof that $144 \div 8 = 18$ is that $18 \times 8 = 144$, *i.e.* the divisor and quotient multiplied together produce the dividend.

In applying this principle to other cases of division, it is not necessary actually to separate the dividend into parts before commencing the process: the same may be done more concisely during the working. Thus, let it be required to divide 11115 by 9. The question is to find a number which multiplied by 9 will give 11115; but that number will be ascertained by finding out how often 9 can be subtracted from 11115. We might therefore proceed to subtract 9 continually, as we formerly did 23, until the dividend is exhausted; but it will obviously not affect the result to subtract as many *nines* at a time as we may find convenient, taking care to mark, at each step, how many are taken away.

11115	
9000	1000 times 9
2115	
1800	200 times 9
315	
270	30 times 9
45	
45	5 times 9
0	1235

Now we at once see that 11115 is greater than 1000 times 9; we therefore take away 9000 at once; the quantity 2115 which remains is greater than 200 times 9 (for $9 \times 200 = 1800$, whereas the remainder has 21 hundreds); we therefore take away 1800, leaving a remainder of 315; this remainder again is greater than 30 times $9 = 270$; this number being subtracted, there remains 45, which we know to be just 5 times 9. Therefore 11115 contains 9 exactly $1000 + 200 + 30 + 5$ times, that is, 1235 times. The working of this process is shown on the margin.

In the above operation it will be observed that we really separated the dividend 11115 into parts in finding that $11115 = 9000 + 1800 + 270 + 45$, and had these parts been known to us previous to commencing the operation, we might have proceeded with the division as here otherwise given on the margin.

$$(1)\ \frac{9000}{9} = 1000$$
$$(2)\ \frac{1800}{9} = 200$$
$$(3)\ \frac{270}{9} = 30$$
$$(4)\ \frac{45}{9} = 5$$
$$\text{Therefore } \frac{11115}{9} = 1235$$

It is obvious now that the only difficulty which can occur, is in finding out how many times we may subtract the divisor at each step, and this is in a great measure removed by considerations of the following kind:—

21 contains 7 3 times; therefore
10 times 21 or 210 contains 7 30 times,
100 times 21 or 2100 contains 7 300 times,
1000 times 21 or 21000 contains 7 3000 times.

15 contains 5 more than 2 times; therefore
150 contains 5 more than 20 times,
1500 contains 5 more than 200 times,
15000 contains 5 more than 2000 times.

18	contains	7	more than	2	times, and	less than	3 times,
180	contains	7	more than	20	times, and	less than	30 times,
1800	contains	7	more than	200	times, and	less than	300 times,
18000	contains	7	more than	2000	times, and	less than	3000 times,
180000	contains	7	more than	20000	times, and	less than	30000 times.

To illustrate these principles, let it be required to divide 40761 by 7; that is, to find $\dfrac{40761}{7} = ?$

Here the first figure, 4, of the dividend is less than 7; the quotient sought is therefore less than 10000, for 10000×7 gives 70000, which exceeds 40761. But we observe that 40, the first and second figures together, contain 7 more than 5 times, and less than 6 times; therefore 40,000 contains 7 more than 5000 times, and less than 6000 times. But 40761 also contains 7 more than 5000 times, for 40761 is greater than 40000; it also contains 7 less than 6000 times.

* We ought properly to say that 4 *does not contain* 8, but the expression 0 times is equally intelligible, and is preferable on the score of uniformity.

because 6000 times 7 is 42000, a greater number than 40761. We may therefore subtract 5000 times 7 (=35000) from 40761, which leaves a remainder of 5761. The quotient sought is therefore $5000+\frac{5761}{7}$. It remains now to find how many times 5761 contains 7. Proceeding as before, we observe that 5 does not contain 7, but that 57 does contain it more than 8 times, and less than 9 times; therefore 5700 contains it more than 800 times, and less than 900 times; as does 5761; subtracting the 800 times 7, or 5600, there remains 161. The quotient is therefore $5000+800+\frac{161}{7}$. Now 16 contains 7 more than 2 times and less than 3 times; therefore, 160 contains 7 more than 20 times, and less than 30 times; as does also 161; subtracting then 20 times 7, or 140, there remains 21. Now, 21 contains 7 just 3 times; and this being subtracted, the dividend is exhausted. We therefore conclude that $\frac{40761}{7}=5000+800+20+3=5823$.

```
40761
35000 = 5000 times 7
-----
 5761
 5600 =  800 times 7
-----
  161
  140 =   20 times 7
  ---
   21
   21 =    3 times 7
   --
    0
-----
40761 = 5823 times 7
```

The following examples may be gone over similarly:—

$$\frac{1656}{3}=552 \quad \frac{8765}{5}=1753 \quad \frac{97587}{7}=13941.$$

The same method is applicable, however great the divisor is. One other example will make this plain:—Divide 4298689 by 576.

We here observe, that it takes the four figures on the left of the dividend, namely, 4298, to make a number which is greater than 576, the divisor: the dividend is therefore separated into 4298000 and 689. Now, 4298 is found to contain 576 more than 7 and less than 8 times; therefore 4298000 contains it more than 7000 and less than 8000 times; and subtracting 576×7000 from the dividend, the remainder is 266689. The four figures, namely 2666, on the left of this remainder, contain 576 more than 4 and less than 5 times, therefore the whole remainder contains it more than 400 and less than 500 times; and 576×400 being subtracted, there arises the new remainder. With this the same operation is repeated until it appears that the quotient is

```
4298689
4032000 = 7000 times 576
-------
 266689
 230400 =  400 times 576
 ------
  36289
  34560 =   60 times 576
  -----
   1729
   1728 =    3 times 576
   ----
      1 remainder.
```

$$7000+400+60+3 \text{ and } 1 \text{ over}=7463+1.$$

It will be observed, on examining the foregoing examples, (1) That it is unnecessary to write the ciphers which are placed on the right of each subtrahend, provided we take care to keep the significant figures in their proper places without them; (2) that it is unnecessary to put down those figures of the dividend which fall over ciphers, as they do not begin to be of use in forming the quotient until significant figures fall under them; and (3) that the figures of the quotient might be written in succession in the usual way. The last example is shown in this abridged form at the side, and it is particularly to be remarked: (1) *That one figure of the given dividend appears on the right of every partial dividend.* (2) *That for every figure of the dividend not employed in the first partial division, there is a quotient figure of the same order.*

```
Divisor. Dividend. Quotient.
576)4298689(7463
    4032
    ----
     2666
     2304
     ----
      3628
      3456
      ----
       1729
       1728
       ----
          1
```

From the nature of the numeration scale, it is obvious that no partial quotient can exceed 9, which is the highest number expressed by only one figure; should a partial product come out 10 or more, there has been an error in the preceding step.

From the foregoing principles, the following rules for division are deduced:—

I. *Write the divisor and dividend in one line, and place reversed parentheses one on each side of the dividend.*

II. *Cut off from the left of the dividend, the smallest number of figures which make a number as great or greater than the divisor; find what number of times the divisor is contained in these, and write the figure which results, as the first in the quotient.*

III. *Multiply the divisor by the quotient figure, and subtract the product of these from the number which was cut off as a partial dividend from the left of the given dividend.*

If the product cannot be subtracted, that is, if it is greater than the part of the dividend cut off, the figure placed in the quotient is too great, and a less figure must be taken. On the other hand, if after the subtraction the remainder be greater than the divisor, the quotient figure taken has been too small, and a greater one must be used.

IV. *On the right of the remainder place the figure of the dividend which comes next after those taken at first according to Rule* II.; *find how often this number contains the divisor, and place the resulting figure on the right of the first figure of the quotient; multiply the divisor by it, and subtract the product from the partial dividend.*

Should it happen at any time that the remainder, increased by the figure of the dividend taken down, is less than the divisor, a 0 must be placed in the quotient, and another figure of the dividend brought down; and this must be repeated, if necessary, until the augmented remainder is capable of containing the divisor, or the figures of the dividend are exhausted.

V. *Proceed with all subsequent partial dividends as directed in Rule* IV., *continuing the process till all the figures of the dividend are brought down.*

The following example simply but amply illustrates this rule:—

```
Divisor. Dividend. Quotient.
251)577556(2301
    502
    ---
     755
     753
     ---
       256
       251
       ---
Remainder 5
```

```
Proof.
  2301 Quotient.
   251 Divisor.
  ----
  2301
 11505
 4602
     5 Remainder.
------
577556 Dividend.
```

Here we take the first three figures on the left of the dividend as our first partial dividend, and dividing these by the divisor, we write in the quotient the number resulting from the division, *i.e.* 2, and multiply the divisor by this number. We now write the product 502 under the partial dividend 577. The subtraction being performed, we bring down the 5 of the hundreds of the dividend, and annex that figure to the remainder, 75. We again divide this new partial dividend by the divisor, and obtain 3, which we place as the second figure in the quotient; multiplying the divisor by this number, we subtract the product 753. To the remainder, 2, we annex 5, the tens' figure of the dividend, making a partial dividend 25. As this does not contain the divisor (or, as for the sake of uniformity we express it, 25 *contains* 251 0 *times*), we write 0 for the next figure of the quotient, and bring down 6, the units' figure of the dividend, making the partial dividend 256. This contains the divisor *once;* we therefore write 1 in the units' place of the quotient, and, subtracting the divisor (that is, $251\times1=251$) from the partial dividend 256, get as a remainder 5. Therefore $577556\div251=2301+5$.

When, as in the foregoing example, the divisor contains several figures, some difficulty may be felt in discovering how often it is contained in the partial dividend. Nothing but practice can enable us to do this with facility—with every one it is a sort of guess-work—yet the difficulty is not, in reality, so great as it, in general, appears to the beginner. The following example will show how it is accomplished:—Divide 423405 by 485

Taking the four figures on the left of the dividend to form a number capable of containing the divisor, we do not see immediately how often 4234 contains 485. To aid us in guessing, we observe that 485 is between 400 and 500, and that if it were either the one or the other of these numbers, the question would be reduced to finding how often 4 or 5 is contained in 42. The reason is that 4 or 5 is contained in 42 as often as 400 or 500 is in 4200, and this last differs little from 4234. We see now that our quotient figure cannot be greater than 10, nor less than 8; it cannot be so great as 10, for on that supposition the three figures on the left of the dividend would contain the divisor *once*, which they do not. It only remains, then, to try whether 9 or 8 (employed as a multiplier of 485) yields a product which can be subtracted from 4234, and we find that it is 8; 8, therefore, is the first figure of the quotient. When $485 \times 8 = 3880$ is subtracted, and the next figure (0) of the dividend annexed, we find that the second partial dividend is 3540. Reasoning upon our divisor as before, we observe that the next quotient figure cannot be greater than 8, nor less than 7; but as 485 is nearer to 500 than to 400, we try 7, which results from a division of 35 by 5; the supposition turns out to be correct; for $485 \times 7 = 3395$, and this subtracted from 3540 leaves 145, which is less than the divisor. By annexing 5 to 145, we get 1455, our third partial dividend, and as 1455 approaches to 1500, and 485 to 500, we try 3 for our next quotient figure, and find that $485 \times 3 = 1455$.

```
485)423405(873
    3880
    ----
     3540
     3395
     ----
      1455
      1455
      ----
         0
```

It would now be highly advantageous to test the foregoing instructions with the following examples:—

$$\frac{3978}{17} = 234, \quad \frac{6321}{21} = 301, \quad \frac{197028}{234} = 842.$$

Prove that $224091 = 4309 \times 52 + 23$.

Also, that $\frac{224091 - 23}{2} = 4309 \times 26$.

Is $215514 = 1781 \times 121 + 13$?

THE LATIN LANGUAGE.—CHAPTER V.

VERBS: CONJUGATION—VOICE—MOOD—TENSE—NUMBER—PERSON—ESSE AND POSSE.

SPEECH is used to register and communicate thought. Predication (*prædico*, I publish or proclaim) is the setting forth of thought. The chief word in predication is a *verb*. By that, the relations of subject to subject or subject to object are expressed. Verbs affirm or deny the state, condition, characteristics, or activities of things and persons. They not only declare facts but enounce opinions, express feelings, and indicate determinations. Pure thought may be indicated by the relation of subject and predicate; but almost all thought is bound to take note of the time and circumstances which bear rule among things. Things and persons exist, think, feel, suffer and cause suffering, change and are changed. The verb is the word which is employed to state in due form all the changes which thought finds it requisite to express. In nouns, the chief changes which occur in things are indicated by cases; in verbs, the changes which take place in man's relation to things, and theirs to him, as well as theirs to each other, have been brought together in certain forms called *conjugations*. Man finds that he must distinguish between energy confined within persons or things, or passing out in action and producing effects and causing changes. Hence we have *voices*—active and passive—and classify verbs into transitive or intransitive. Experiences differ in the manner in which they are done and received, and hence the verb takes the distinction of *mood*. All that we know operating around us, we know as influenced by time, and therefore *tense* becomes an adjunct of the verb. Different persons are differently related to one another and to the experiences with which the world is filled, and their numbers may be one or many, hence we have *singular* and *plural* number. All those peculiar modifications possible to thought and action require to be in some cases incorporated with, in others attached to, the verb. In Latin the former plan prevails, in English the latter.

The Latin verb indicates in its *form*—voice, mood, tense, number, and person. This it does by various changes made in and on its form, mainly by the affixing of a variety of terminations. Sometimes several suffixes are added to one verb, each of which requires in English a distinct word to express its meaning. Thus a Latin verb is often equivalent to several English words; as *dixerim*, I might have spoken.

It is a highly important thing therefore to acquire an accurate knowledge of these various terminations. That we may be able readily to learn to distinguish these different terminations, grammarians have gathered, from all extant literature, words of similar form, arranged them in order, and deduced from them a plan by which they may be presented in systematic order in a series of paradigms. A few necessary explanatory remarks require to be made in order that the student may see in the paradigms what they are intended to show him, and to understand not only their meaning when seen, but their use when he requires to apply the knowledge he there gains to practical purposes. These observations will be found given in order in the succeeding paragraphs.

A verb is grammatically conjugated when all its parts are properly classed, or, as it were, *yoked together*, according to voice, mood, tense, number, and person.

A Latin verb is, however, in common usage said to be conjugated when only its principal parts—present, perfect, supine, and infinitive—are mentioned, because from them all the rest are derived.

There are four conjugations of verbs:—

I. The First Conjugation is known by *ā* before *re* of the infinitive; as *ămāre*, to love; *laudāre*, to praise; *culpāre*, to blame; *pugnāre*, to fight.

II. The Second Conjugation is known by *ē* before *re* of the infinitive; as *mŏnēre*, to advise; *flēre*, to weep; *manēre*, to remain; *sedēre*, to sit.

III. The Third Conjugation is known by *ĕ* before *re* of the infinitive; as *rĕgĕre*, to rule; *currĕre*, to run; *induĕre*, to put on; *arguĕre*, to argue.

IV. The Fourth Conjugation is known by *ī* before *re* of the infinitive; as *audīre*, to hear; *nutrīre*, to nourish; *erudīre*, to instruct; *finīre*, to bring to an end.

Verbs have two voices: I. Active; as *ămo*, I love; II. Passive; as *ămor*, I am loved.

Active and deponent verbs are of two kinds: transitive, *i.e.* acting on an object, as *amo eum*, I love him; or intransitive, *i.e.* not acting on an object, as *sto*, I stand.

A deponent verb is for the most part passive in form, but active in sense; as *hortor*, I exhort.

Such verbs receive the name because they lay aside (*dēpōno*) their passive signification and their active form, being in fact only the passive voice of obsolete active verbs. Though, however, their active signification is preserved, yet the participle in *-dus* has always a passive sense; as *loquendus*, to be spoken. Intransitive verbs have only the neuter form of this participle, which in the nominative and accusative is called the gerund of necessity; as *Moriendum est omnibus*, All must die.

Intransitive verbs cannot take a personal passive.

Besides the foregoing classification of verbs into active, passive, and deponent, and these again into transitive and intransitive (or neuter), grammarians name and distinguish the following subclasses:—Substantive, Neuter, Neuter-passive, Common, Desiderative, Inceptive, Frequentative.

A *substantive* verb expresses being or existence. The substantive verbs are *sum*, I am; *fŏrem*, I might be; *existo*, I exist.

A *neuter* verb expresses neither action nor suffering, but simply the state, posture, or quality of its nominative; as *palleo*, I am pale; *sĕdeo*, I sit.

A *neuter-passive* verb is partly active and partly passive in termination, and is active, passive, or neuter in signification; as *audeo*, I dare; *gaudeo*, I rejoice; *exulo*, I am banished; *fīō*, I am made, or become; *vāpŭlo*, I am beaten; *vēneo*, *venii*, I am sold.

Neuter-passives receive their name from having a perfect

passive in form; as *audeo, ausus sum, audēre*, to dare; *fido, fīsus sum, fīdĕre*, to trust; *gaudeo, gavīsus sum, gaudēre*, to rejoice; *sŏleo, solĭtus sum, solēre*, to be wont.

A verb which has a passive termination, but is used with an active and passive signification, is called *common;* as *crimĭnor*, I accuse or I am accused.

A *desiderative* verb is one in which a desire to do something is expressed. Desideratives are formed from the supine by changing *m* into *rio;* as *cœno*, I sup; *cœnatum, cœnatŭrio*, I desire to sup. They are all of the Fourth Conjugation, and—except *esŭrio*, I wish to eat, which is regularly conjugated; and *partŭrio*, I bring forth, and *nuptŭrio*, I desire to be married, which have the perfect—they have neither perfect nor supine.

An *inceptive* verb expresses the beginning or continuing increase of the action or state denoted by the primitive; as *caleo*, I am warm; *calesco*, I grow warm. Inceptives are formed from the second person singular of the present indicative, by adding *co;* as *căleo, căles, căles-co.* They are all neuter and of the Third Conjugation. They want both perfect and supine. Inceptives are likewise formed from nouns and adjectives; as *puĕrasco*, from *puer*, a boy; *dulcesco*, from *dulcis*, sweet.

A *frequentative* verb implies a frequent repetition of an action, or an increase of the signification denoted by the primitive; as *clāmĭto*, I cry frequently, from *clamo*, I cry. Frequentatives are formed from the supine, by the change of *ātum* into *ĭto* in verbs of the First, and of *um* into *o* in verbs of the other Conjugations; *căno, cantum, canto*, I am in the habit of singing. They are all of the First Conjugation, and end in *ĭto, so, xo*, and (when deponent) in *or*.

Verbs have two parts: (1) finite; (2) infinite.

(1) The verb finite has three moods:—

1. The indicative mood; as *ămo, mŏneo, rĕgo, audio.*
2. The subjunctive mood; as *ămem, mŏneam, rĕgam, audiam.*
3. The imperative mood; as *ămā, mŏnē, rĕgĕ, audī.*

The indicative represents a state or action simply as a fact; as *laudo*, I praise; *laudŏr*, I am praised.

The subjunctive represents a state or action as possible, conceivable, or desirable; as *opto ut vĕniat*, I wish that he may come.

The imperative represents a state or action in the form of a command; as *scrībĭtĕ*, write ye.

The term *mood* implies technically, in Latin, a special form of thought, indicated by a certain variety of terminal suffix, by which what is expressed in the word shows that it is either a main or a subordinate idea, and therefore whether the sentence in which it has its place is a principal or a dependent one. Principal sentences convey a complete (indicative) meaning and can stand alone, while dependent sentences express only an imperfect sense, being employed to qualify or explain principal sentences, to which of course they must always be conjoined (subjunctive).

(2) The verb infinite takes several forms, viz.

1. The infinitive mood, which has several tense-forms, and consists of what might be called verbal nouns, used in all cases except the vocative.
2. The four gerunds, } Verbal nouns, which supply several
3. The two supines, } cases to the infinitive.
4. Two participles or verbal adjectives in each voice, one of which ends in *dŭs*, and is called the gerundive.

The infinitive represents in the most general and indefinite manner the name of an action or state; as *scrībĕre*, to write; *scripsisse*, to have written.

The gerund, which, like the infinitive, expresses a state or action in a general way, is a verbal noun ending in *ndum.* It is used only in its oblique cases; as gen. *ămandi*, dat. *ămando*, acc. *ămandum*, abl. *ămando.* The place of the nominative is supplied by the infinitive *ămāre.* This is shown fully in the subjoined examples:—nom. *dŏlēre*, grieving; gen. *dŏlendi*, of grieving; dat. *dŏlendo*, to grieving; acc. *dŏlēre*, grieving (*ad dŏlendum*, to grieve); abl. *dŏlendo*, by grieving. The accusative is *dŏlendum* only when governed by a preposition.

The supine, which may be classed among nouns, so far at least as its form is concerned, is declinable, but has only an accusative in *um* and an ablative in *u;* as *audītum* and *audītu.*

The participles are in form adjectives derived from verbs; but they retain the idea of time which is inherent in the signification of a verb. A verb may have two participles in the active and two in the passive. Those in the active are the present, ending in *ns* for all genders, and the future, ending in *-ūrus, -a, -um;* the former represents the action as in progress, and the latter as about to take place; as *ămans*, loving; *scrīpturus*, about to write. The two participles of the passive are the past participle, ending in *-us, -a, -um*, and the gerundive, ending in *-ndus, -nda, -ndum;* the former represents an action in a state of completion, the latter indicates that it is going on or must take place; as *audītus*, heard; *audiendus*, to be heard.

Verbs have also forms for the expression of time. Time is either (1) simply present, past, or future; or it is (2) present, past, or future with some further relation. Therefore there are six tense-forms:—

(1) Three tenses of unfinished action, viz. present, imperfect, future (simple).

(2) Three tenses of finished action, viz. perfect, pluperfect, future perfect.

The tenses may also be distinguished as either (1) absolute or (2) relative.

Absolute, *i.e.* without mention or implication of modifying circumstances; as present, *ămo*, I love; perfect, *ămāvi*, I have loved; future, *ămābo*, I will love.

Relative, *i.e.* depending on some other action; as imperfect, *ămābam*, I was loving, *i.e.* when something else happened; perfect (when used as an aorist), *ămāvi*, I loved, *i.e.* at some time which I need not specify particularly; pluperfect, *ămāvĕram*, I had loved, *i.e.* when something else happened; second future or future perfect, *ămāvĕro*, I shall have loved, *i.e.* when something else has happened.

The present, the futures, and the present past (*amāvi*, I have loved) are called primary tenses; the imperfect, pluperfect, and perfect aorist (*amāvi*, I loved) historic tenses.

In each tense there are two numbers, singular and plural, and in each number three persons, of which the grammatical distinction is that the first person speaks; as *amo*, I love; *amāmus*, we love. The second person is spoken to; as *amās*, thou lovest; *amātis*, ye love. The third person is spoken of; as *amat*, he loves; *amant*, they love.

Such verbs as have different persons are called verbs personal; as *ego amo*, I love; *tu amās*, thou lovest; *ille amat*, he loves. But such as do not take different persons, that is, are used in the third person singular only, are called verbs impersonal; as *tædet*, it irks; *oportet*, it behoves.

The tenses are thus formed from the four principal parts, viz. (1) the present, ending in *o;* (2) the perfect, in *i;* (3) the supine, in *um;* and (4) the infinitive, in *re;* as present, *ămo;* perfect, *ămāvi;* supine, *ămātum;* infinitive, *ămāre.*

They may be tabulated thus:—

Present.	*Imperf.*	*Fut. simp.*	*Pres. subj.*	*Part. pres.*	*Gerunds.*
Am-o	ābam	ābo	em	ans	an-di } do, dum
Mŏn-eo	ēbam	ēbo	eam	ens	en-di } do, dum
Vert-o	ēbam	am	am	ens	en-di } do, dum
Aud-io	iēbam	iam	iam	iens	ien-di } do, dum

Perf.	*Plup.*	*Fut. perf.*	*Perf. subj.*	*Plup. subj.*	*Perf. infin.*
Amāv- } i	ĕram	ĕro	ĕrim	issem	isse.
Monu- } i					
Vert- } i					
Audīv- } i					

Supine act.	*Sup. pass.*	*Part. pass.*	*Part. fut. act.*
Amāt- } um	ū	ŭs, ă, um	ūrŭs, ă, um
Mŏnit- } um			
Vers- } um			
Audīt- } um			

Infin.	*Imp. subj.*	*Imp. act.*	*Inf. pass.*
Am-āre	ārem	ā	āri.
Mŏn-ēre	ērem	ē	ēri.
Vert-ĕre	ĕrem	ĕ	i.
Aud-īre	īrem	ī	īri.

To form the tenses of the passive voice from the active add *r* to *o* final, or change *m* final into *r;* as active *amābo*, passive *amābor;* active *amem*, passive *amer*.

For the perfect passive and the tenses belonging to or formed from it use the passive participle and parts of the verb *sum*.

The imperative passive is always the same as the infinitive active.

CONJUGATION OF VERBS.

Conjugation is the complete formal inflexion of a verb from its root, through the various relations of mood, tense, number, and person.

Verbs regular are such as are formed according to the general rules.

The term *irregular* is applied to those verbs which depart from the rule in the formation of their perfect and supine, but more especially to those which, like *sum* and its compounds, have something anomalous in their conjugation itself.

The root-tense of the verb is the first person singular of the indicative; as *ămo*, *moneo*, *rego*, *audĭo*; and the more important tenses of the active voice, next to the root-tense, are three:—

(1) The present infinitive; as *ămāre, mŏnēre, regĕre, audīre.*
(2) The perfect indicative; as *ămāvi, mŏnui, rexi, audīvi.*
(3) The active supine; as *ămātum, mŏnĭtum, rectum, audītum.*

These are usually arranged for practical use as follows:—

ACTIVE VOICE.

Conj.	*Pres.*	*Perf.*	*Sup.*	*Infin.*	
1.	Amo,	ămāvi,	ămātum,	ămāre,	*to love.*
2.	Mŏneo,	mŏnui,	mŏnĭtum,	mŏnēre,	*to advise.*
3.	Verto,	verti,	versum,	vertĕre,	*to turn.*
4.	Audio,	audīvi,	audītum,	audīre,	*to hear.*

PASSIVE VOICE.

Conj.	*Pres.*	*Perf.*	*Infin.*	
1.	Amor,	ămātus sum *or* fui,	amāri,	*to be loved.*
2.	Mŏneor,	mŏnĭtŭs sum *or* fui,	monēri,	*to be advised.*
3.	Vertor,	versŭs sum *or* fui,	verti,	*to be turned.*
4.	Audior,	audītŭs sum *or* fui,	audīri,	*to be heard.*

When these tenses are once known, all the others flow so naturally from them that it seems really needless to encumber the memory by a separate rule for each individual tense. The following rhyme has been composed as a help in remembering the mode of forming the tenses one from another:—

From *o* are formed both *am* and *em;*	Present.
From *i*, *ram*, *rim*, *ro*, *sse*, and *ssem*.	Perfect.
U, *us*, and *rus* are formed from *um*,	Supine.
All other parts from *re* do come, As *bam*, *bo*, *rem*, *a*, *e*, and *i*, With *us* and *dus*, *dum*, *do*, and *di*.	Infinitive.

The first person of the present of the indicative is called the theme or the root of the verb, because from it the other three principal parts are formed.

The letters of a verb which always remain the same are called radical letters; as *am* in *ăm-o*. The rest are called the termination; as *ābămus* in *ăm-ābămus*.

All the letters which come before *-āre*, *-ēre*, *-ĕre*, or *-īre* of the infinitive are radical letters. By putting these before the terminations all the parts of any regular verb, except the compound tenses, may be readily formed.

So far as regards the First, Second, and Fourth Conjugations, little difficulty can arise in knowing how the perfect and supine are formed, but in the Third considerable difficulty presents itself. For such special cases rules will be subsequently provided, but for the present the following general principles will be found sufficient for most ordinary purposes:—

The perfect is formed in several ways—

(1) By adding *vī* to the root; as *ămāvī*, *flēvī*.
(2) By adding *ŭī* (for *vī*) to the root (or the root without its final vowel, which is elided before or absorbed into the termination); as *cŏlŭī*, *mŏnŭī*.
(3) By adding *sī* to the verbal root; as *carpsī*, *mansī*.

In this formation consonants are generally changed when the terminal of the root is *e*, *g*, *h*, or *qu*, into *x;* *b* becomes *p* before *si;* *d* is either dropped, or, if it is retained, the *s* of *si* is omitted; *e.g. dūco, duxi; rĕgo, rexi; traho, traxi; coquo, coxi; scribo, scripsi; claudo, clausi; defendo, defendi*, &c.

(4) By prefixing a reduplication and adding *ī* to the root. This reduplication is either the first consonant and vowel of the stem, as *cŭcurrī*, *mŏmordī;* or the first consonant with *ĕ*, in which case the root-vowel is usually changed, as *cĕcĭnī* (from *cănō*).

(5) By adding *ī* to the root, with or without change of the root-vowel; as *bĭbī*, *vertī*, *ēgī* (from *ăgō*), *fāvī* (from *făvĕō*).

The supine is formed—

(1) By adding *tum* (sometimes *ĭ-tum*) to the root, and a change of letters often takes place by elision or contraction; as *amātum, cultum, rectum, mŏn-ĭ-tum.*

(2) The change of letters often requires *tum* to become *sum*.

The personal pronouns, which are for the most part added to the verb in English, are in Latin commonly understood; because in the latter the several persons are sufficiently distinguished from each other by the different terminations of the verb, though the personal pronouns themselves be not expressed. The learner ought, however, at first to accustom himself to join them with the verb; thus, *ĕgo sum*, I am; *tū es*, thou art *or* you are; *illĕ est*, he is; *nōs sŭmŭs*, we are, &c. So *ego amo*, I love; *tu amas*, thou lovest; *illī amant*, they love.

In the second person singular the English commonly use the plural form, except in solemn discourse; *e.g. tū ĕs*, thou art, is much oftener expressed you are; similarly *tū ĕras*, thou wast *or* you were; *tu sīs*, thou mayst be *or* you may be; *ĕs* or *esto tū*, be thou *or* be (ye) you, &c.

The verb *esse* is called a *substantive* verb because it is the most general verb used to express existence, and it receives the name of an *auxiliary* verb because it is employed in the formation of the tenses of other verbs. It is also classed as an *irregular* verb, on account of its being made up of different roots: (1) *es-um*, Greek εἰμί, ἐσμί, Sanskrit *as-mi*, indicative of continuance in being; and (2) *fu*, Greek φύω, Sanskrit *bhû*, denoting coming into being.

INDICATIVE MOOD.

PRESENT TENSE.

Singular.		*Plural.*	
1. Sŭm,	*I am.*	1. Sŭmŭs,	*we are.*
2. Es,	*thou art.*	2. Estĭs.	*you are.*
3. Est,	*he is.*	3. Sunt,	*they are.*

PAST (IMPERFECT) TENSE.

Singular.		*Plural.*	
1. Eram,	*I was.*	1. Erāmŭs,	*we were.*
2. Erās,	*thou wast.*	2. Erātĭs,	*you were.*
3. Erăt,	*he was.*	3. Erant,	*they were.*

FUTURE TENSE.

Singular.		*Plural.*	
1. Ero,	*I shall* or *will be.*	1. Erĭmŭs,	*we shall* or *will be.*
2. Erĭs,	*thou shalt* or *wilt be.*	2. Erĭtĭs,	*you shall* or *will be.*
3. Erĭt,	*he shall* or *will be.*	3. Erunt,	*they shall* or *will be.*

PERFECT TENSE.

Singular.		*Plural.*	
1. Fuī,	*I have been.*	1. Fuĭmŭs,	*we have been.*
2. Fuistī,	*thou hast been.*	2. Fuistĭs,	*you have been.*
3. Fuĭt,	*he has been.*	3. Fuĕrunt *or* fuēre,	*they have been*

PAST (PERFECT) TENSE.

Singular.		*Plural.*	
1. Fuĕram,	*I had been.*	1. Fuĕrāmŭs,	*we had been.*
2. Fuĕrās,	*thou hadst been.*	2. Fuĕrātĭs,	*you had been.*
3. Fuĕrăt,	*he had been.*	3. Fuĕrant,	*they had been*

FUTURE (PERFECT) TENSE.

Singular.		*Plural.*	
1. Fuero,	*I shall* or *will have been.*	1. Fuĕrĭmŭs,	*we shall* or *will have been.*
2. Fuĕris,	*thou shalt* or *wilt have been.*	2. Fuĕrĭtĭs,	*you shall* or *will have been.*
3. Fuĕrĭt,	*he shall* or *will have been.*	3. Fuĕrint,	*they shall* or *will have been*

Subjunctive Mood.

PRESENT TENSE.

Singular.		*Plural.*	
1. Sim,	*I may be.*	1. Sīmŭs,	*we may be.*
2. Sīs,	*thou mayst be.*	2. Sītĭs,	*you may be.*
3. Sĭt,	*he may be.*	3. Sint,	*they may be.*

PAST (IMPERFECT) TENSE.

Singular.	*Plural.*
1. Essem *or* forem, *I might be.*	1. Essēmŭs *or* forēmus, *we might be.*
2. Essēs *or* forēs, *thou mightst be.*	2. Essētĭs *or* forētis, *you might be.*
3. Essĕt *or* forĕt, *he might be.*	3. Essent *or* forent, *they might be.*

PERFECT TENSE.

Singular.	*Plural.*
1. Fuĕrim, *I may have been.*	1. Fuĕrimŭs, *we may have been.*
2. Fuĕris, *thou mayst have been.*	2. Fuĕritīs, *you may have been.*
3. Fuĕrĭt, *he may have been.*	3. Fuĕrint, *they may have been.*

PAST (PERFECT) TENSE.

Singular.	*Plural.*
1. Fuissem, *I might have been.*	1. Fuissēmŭs, *we might have been.*
2. Fuissēs, *thou mightst have been.*	2. Fuissētĭs, *you might have been.*
3. Fuissĕt, *he might have been.*	3. Fuissent, *they might have been.*

Imperative Mood.

PRESENT TENSE.

Singular.	*Plural.*
2. Es, *be, be thou,* or *do thou be.*	2. Estĕ, *be, be ye* or *you, do ye be.*

FUTURE TENSE.

Singular.	*Plural.*
2. Esto, *thou shalt be.*	2. Estōtĕ, *ye* or *you shall be.*
3. Esto, *he shall be* or *let him be.*	3. Sunto, *they shall be, let them be.*

Infinitive Mood.

PRESENT TENSE.	PERFECT TENSE.
Essĕ, *to be.*	Fuissĕ, *to have been.*

FUTURE TENSE.	FUTURE PARTICIPLE.
Forĕ (indecl.) *or* fŭtūr-ŭs, -a, -um esse, *to be about to be.*	Fŭtūr-ŭs. -a, -um, *about to be.*

The verb *esse* has neither gerunds nor supines.

The compounds of the verb *sum* are—

Absum,	abfuī,	abesse,	*I am absent.*
Adsum,	adfuī,	adesse,	*I am present, I stand by.*
Dēsum,	defuī,	deesse,	*I am wanting.*
Insum,	infuī,	inesse,	*I am in* or *at a place.*
Intersum,	interfuī,	interesse,	*I am among.*
Obsum,	obfuī,	obesse,	*I am in the way, am hurtful to.*
Præsum,	præfuī,	præesse,	*I am at the head of.*
Prōsum,	profuī,	prodesse,	*I am useful, I do good.*
Subsum,	subfuī,	subesse,	*I am under.*
Supersum,	superfuī,	superesse,	*I remain over, I survive.*

These are all conjugated like *sum*, only that *prō-sum* takes *d* before the persons of the verb *sum* which begin with *e*; as pres. ind. *prō-sum, prod-ĕs, prod-est,* &c.

Only *absum, possum,* and *præsum* have present participles, viz. *absens,* absent, *potens,* powerful, *præsens,* present.

Possum, I am able, I can, is composed of *pŏtis, pŏte,* able, and *sum;* by dropping the termination of *pŏtis* and assimilating *t* into *s* when it comes before *s*, we obtain *potsum, possum.* It therefore follows the conjugation of *sum* in its terminations, but the consonants *t, s,* and *f* are liable to modification or changes for euphony, by syncope, and by contraction when they come together. Hence it will be advisable to set *Possum* forth at length.

Indicative Mood.

PRESENT TENSE.

Possum,	potĕs,	potest,	*I can, &c.*
Possŭmus,	potĕstis,	possunt,	*We can, &c.*

IMPERFECT TENSE.

Pŏtĕram,	pŏtĕrās,	potĕrat,	*I could, &c.*
Pŏtĕrāmus,	pŏtĕrātis,	potĕrant,	*We could, &c*

FUTURE TENSE.

Pŏtĕro,	pŏtĕris,	pŏtĕrit,	*I shall* or *will be able, &c.*
Pŏtĕrĭmus,	pŏtĕrĭtis,	pŏtĕrunt,	*We shall* or *will be able, &c.*

PERFECT TENSE.

Pŏtui,	pŏtuisti,	potuit,	*I was able, &c.*
Pŏtuĭmus,	pŏtuistis,	ērunt *or* ēre,	*We were able, &c.*

PLUPERFECT TENSE.

Pŏtuĕram,	pŏtuĕrās,	potuĕrăt,	*I had been able, &c.*
Pŏtuĕrāmus,	pŏtuĕrātis,	potuĕrant,	*We had been able, &c.*

FUTURE PERFECT TENSE.

Pŏtuĕro,	pŏtuĕrīs,	potuĕrit,	*I shall have been able, &c.*
Pŏtuerimŭs,	pŏtuĕritis,	potuerint,	*We shall have been able, &c.*

Subjunctive Mood.

PRESENT TENSE.

Possim,	possis,	possīt,	*I may be able, &c.*
Possimŭs,	possītis,	possint,	*We may be able, &c.*

IMPERFECT TENSE.

Possem,	possēs,	possĕt,	*I should be able, &c.*
Possēmŭs,	possētĭs,	possent,	*We should be able, &c.*

PERFECT TENSE.

Pŏtuĕrim,	ĕris,	ĕrit,	*I have* or *may have been able, &c.*
Pŏtuĕrimus,	ĕritis,	int,	*We have* or *may have been able, &c.*

PLUPERFECT TENSE.

Pŏtuissem,	issēs,	issĕt,	*I might have been able, &c.*
Pŏtuissēmŭs,	issētĭs,	issent,	*We might have been able, &c.*

(No Imperative Mood.)

Infinitive Mood.

PRESENT and IMPERFECT.	PERFECT and PLUPERFECT.
Pŏsse, *to be able.*	Pŏtuisse, *to have been able.*

Participle.

(Pŏtens has become an adjective, meaning powerful.)

Possum has neither gerunds nor supines.

The student ought very carefully to commit the entire verb *sum* to memory. It comes into very frequent use, expressed or understood; but besides this it forms in a great measure a mnemonic for the terminal syllables of the regular conjugations of Latin verbs; *e.g.*—

Am, ās, ăt, āmŭs, ātĭs, ant give a key to the finals of the impf. indic.			
I, isti, ĭt, imŭs, istis, ērunt *or* ēre	"	"	perfect.
Eram, erās, ĕrăt, ĕrāmŭs, ĕrātĭs, ĕrant	"	"	pluperfect.
O, ĭs, ĭt, ĭmus, ĭtis, unt	"	"	future.
Ero, eris, erit, erimus, eritis, erint	"	"	future perfect.
Em, ēs, ĕt, ēmŭs, ētĭs, ent	"	"	impf. subj.
Erim, ĕrĭs, ĕrĭt, ĕrĭmŭs, ĕrĭtīs, erint	"	"	perfect.
Issem, issēs, issĕt, issēmŭs, issētĭs, issent		"	pluperfect.
To, te *or* tote, nto	"	"	imperative.

We are now—having got a verb we can use—able to acquire the power of employing Latin words in

SENTENCE-BUILDING OR COMPOSITION.

Every sentence consists of two parts, (1) the subject, and (2) the predicate; as *Inertĭa vĭtĭum est,* Indolence is a vice.

The subject is that of which anything is said, *i.e.* affirmed or denied; as *Dĕŭs est,* God is, God exists, there is a God.

The predicate is that which is said, *i.e.* affirmed or denied of the subject; as *Arbŏrēs vĭrent,* The trees are green.

The subject appears as a noun, or a pronoun, adjective, phrase or part of a sentence used for or representing a noun; as *Rŏsa pulchra est,* The rose is beautiful; *Tū dixistī nĭhĭl,* Thou hast said nothing; *Bŏnŭs semper beātŭs est,* A good (man) is always happy.

The predicate always appears as a verb, either expressed or understood, and with or without complementary adjuncts; as *Tempŭs vitæ magister est,* Time is the lord of life; *Fortēs fortūna adjŭvat,* Fortune helps the brave.

The subject of a verb is naturally in the nominative case; as *Leo est anĭmal,* The lion is an animal.

A verb agrees in number, person, and (where necessary) gender with its nominative; as *Vestī ĕrat indūtŭs tālārī,* He wore a garment down to his ankle.

The following sentences are formed in agreement with the first concord, viz.:—

I. An adjective agrees with a substantive in number, gender, and case—

Dĕŭs est sanctŭs,
God is holy.
Terrā est rŏtundă,
The earth is round.
Mĕl est dulcĕ,
Honey is sweet.
Hŏmĭnĕs sunt mortālēs,
Men are mortal.
Fēmĭnæ sunt formōsæ,
Women are handsome.
Măriă sunt prŏfundă,
Seas are deep.
Opĕră sunt ingentĭă,
The works are extensive.
Mensă est magnă,
The table is large.
Scutum magnum est,
The shield is large.
Liber meŭs parvŭs est,
My book is small.
Mensæ non parvæ sunt sed magnæ,
The tables are not small but large.
Hæ arbŏrēs sunt vĕtustissĭmæ,
These trees are very old.
Lāc est bŏnum,
Milk is good.
Lāc vaccæ album est,
The milk of the cow is white.
Panthēræ et leōnēs fĕræ sunt,
Panthers and lions are wild beasts.
Vĕră amicĭtĭă est sempĭternă,
True friendship is everlasting.

Maxĭmus anĭmăl terrestrĕ est ĕlĕphās,
The elephant is the greatest land animal.
Stellæ pulchræ sunt,
The stars are beautiful.
Agrĭcŏlæ laborĭōsī sunt,
The husbandmen are laborious.
Pāvŏnēs superbī sunt,
Peacocks are proud.
Agrī fertĭlēs sunt,
The fields are fertile.
Palmæ nŏbĭlēs sunt,
The palms are noble.
Fructūs maturī sunt,
The fruits are ripe.
Rex et rēgīnă sunt beātī,
The king and queen are happy.
Laus et impĕrĭum sunt bŏnă,
Praise and power are good things.
Mărĕ salsum est,
The sea is salt.
Cornū curvum est,
The horn is crooked.
Glaciēs lubrĭcă est,
The ice is slippery.
Apis sēdŭlă est,
The bee is industrious.
Vir doctŭs est,
The man is learned.
Rēgīnă pŏtens est,
The queen is powerful.

II. The second law of concord is that substantives signifying the same thing agree in case. To this we must add, as explanatory of the principle of construction in the following sentences, that the verb *esse* has the same case after it that it has before it; that nouns which thus agree in case are said to be put in apposition to one another:—

Ferrum, plumbum, aurum, argentum sunt metalla,
Iron, lead, gold (and) silver are metals.
Flŏs pulchĕr rŏsă est,
The rose is a beautiful flower.
Lignum dōnum est,
The wood is a gift.
Belgæ sunt agrĭcŏlæ,
The Belgians are husbandmen.
Sŏl est lux mundi,
The sun is the light of the world.
Alfred Britanniæ Magnæ rex optĭmŭs fuĭt,
Alfred was a very excellent king of Great Britain.
Macbeth Scotorum rex pessĭmŭs fuit.
Macbeth, king of the Scots, was very wicked.
Alexander rex Măcĕdŏnĭæ fuit,
Alexander was king of Macedonia.
Evă uxor Adamī fuit,
Eve was Adam's wife.

Sarah uxor Abrahamī fuit,
Sarah was Abraham's wife.
Măriamă soror Aarŏnī fuit,
Miriam was Aaron's sister.
Plurimæ stellæ sunt sŏlēs,
Very many stars are suns.
Aprī non cervī sunt,
Boars are not stags.
Aristotĕlēs magnus phĭlŏsŏphus fuit
Aristotle was a great philosopher.
Xerxēs Graciæ rex non fuit,
Xerxes was not king of Greece.
Roma fuit urbs maxima,
Rome was a very large city.
Troja erat urbs Asiæ,
Troy was a city of Asia.
Eurōpă est pĕninsŭlă,
Europe is a peninsula.
Britannia est insŭlă,
Britain is an island.
Australia Britanniæ Magnæ cŏlōniă est,
Australia is a colony of Great Britain.

III. *Esse* is idiomatically used with a dative case after it as an equivalent for the English *to have, belong;* as *Non ĭdem semper flōrĭbŭs cŏlŏr est,* Not the same colour alway is to the flowers = Flowers have not always the same colour; *Malevento nunc Benevento est nomen,* Maleventum has now the name Beneventum.

Dr. John Day Collis has collected the following concise illustrations of this rule:—

Mihi, tibi, ei, illi, nōbis, vōbis, iis, illis est liber *or* sunt libri,
I, thou, he, that person, we, you, they, those have a book or *books.*
Mihi, &c., ĕrăt līber *or* erant libri,
I, &c., have a book or *books.*
Nēmĭnī est liber; nēmĭnī sunt libri,
Nobody has a book or *books.*
Părentĭbus meis ĕrant liber,
My parents had a book.
Părentĭbŭs meis ĕrant, fuerunt, erunt libri,
My parents had, have had, will have books.
Non essent illis libri,
They can have no books.
Ut pătrī meo sit liber *or* sint librī,
That my father may have a book or books.
Quibŭs fuĕrunt libri?
Who have had books?

Quibus est liber *or* sunt libri?
Who has a book or *books?*
Cui ĕrĭt liber?
Who will have a book?
Cui ĕrunt librī?
Who will have books?
Poētīs ĕrĭt liber,
The poets will have a book.
Poētæ erunt libri,
The poet will have books.
Non ĕrit poētis liber,
The poets will not have a book.
Sīt tĭbī liber; sint tĭbī libri,
You may have a book; you may have books.
Est mĭhi pater, mater, frater, sŏrŏr, ăvŭs, avuncŭlŭs, nepos, ŭxŏr, filius, filia, equus, bos, taurŭs, vaccă, quadrīgă, &c.
I have a father, a mother, a brother, a sister, a grandfather, an uncle, a nephew, a wife, a son, a daughter, a horse, a bull, a cow, a carriage, &c.

It will be found exceedingly advantageous to form similar sentences, which may be easily done by the interchange of the nouns used in one sentence with those of another, observing always (1) that good sense is maintained, and (2) that the grammatical structure of the sentences is retained. Plural sentences may easily be made singular and singular ones plural.

PHYSIOLOGY.—CHAPTER V.

SENSATION AND PERCEPTION—THE NERVOUS SYSTEM—CEREBRO-SPINAL—GANGLIONIC—NERVOUS TISSUE—NERVOUS ACTION.

THE whole of the bodily organs of man may be divided into two great classes: (1) those by which he is nourished and grows and reproduces his kind; and (2) those by which he perceives the world, and the outward order of things external to him, and reacts upon them. This division of man's organization has been found to answer all practical physiological purposes. It enables us to explain how the first set of organs are chiefly occupied with merely building up the frame of the body, and have therefore been called *organic,* while the other, or second set of organs, have been called *animal.* Thus we have (1) organs of organic life, and (2) organs of animal life. The *first division* includes the organs

1. Of prehension, ...	The lips.
2. Of mastication, . . .	The teeth.
3. Of insalivation, . . .	The salivary glands.
4. Of deglutition, ...	The cavity of the throat called the pharynx, leading directly into the gullet.
5. Of digestion in its widest sense (*chylopœsis*), .	The stomach, small and large intestines, &c.
6. Of the appendages of the digestive canal, . .	Liver, spleen, pancreas, &c.
7. Of absorption, ...	The lacteal vessels.
8. Of circulation of the absorbed nourishing material, *i.e.* the chyle and blood, . . .	The veins, the arteries, the heart.
9. Of nutrition, ...	The organs included in divisions 6, 7, and 8, and the absorbents.
10. Of respiration, and of the purifying of the blood,	The lungs, kidneys, skin, &c.

These organs construct the animal frame, but they do not quite complete the man. That implies the organs of the senses, and of spontaneous motion from place to place; of perception, of reflection or thought. These organs and their functions are the means by which the animal frame is enabled to avoid what is hurtful to it, and to approach and seek what is calculated to give it pleasure. They include the organs of

voice and speech, and this *second division* may be arranged as including the organs

1. Of sensation, ...	The instruments of the senses: skin, tongue, nose, eyes, ears, and the nerves leading from these to the brain and spinal marrow.
2. Of consciousness, perception, and ratiocination,	The brain.
3. Of reflex action, . . .	The spinal cord.
4. Of muscular action — (1) With consciousness, .	The muscles and certain nerves.
(2) Without consciousness,	Certain muscles, with the nerves supplying them.
5. Of voice, ...	The larynx, &c.

Motion is either automatic, voluntary, or reflex. The movement or change of the position of any part of the body is motion, that of the whole body is locomotion. Partial or total movement is in the human body performed by certain organs, *e.g. cells*, which exhibit amœboid or alternating motion; *cilia*, whose motion is wavy; and *muscles*, which, by their elastic contraction and expansion, not only change the position of parts of the body, but alter the body's position in space. Muscular fibre is only an agent in motion. Into it there seems to grow and be lost those soft white delicate cords of nervous tissue, which are minutely distributed over all the organs of the body which receive sensations and transmit motor-power as the occasion of muscular movements. Sensory nerves, motor nerves, and the central organs or chief seat of *innervation* constitute the *nervous system*. (See Plate X.) This constitutes the link between animal function and mental action. The nervous system conditions external sensation and internal feeling, induces and regulates almost all the automatic and involuntary motions in the body, as well as all the voluntary motions of it, and exerts an indirect influence, which is in a great measure reciprocal, on all the bodily functions.

Nerves consist of primitive *nerve-fibre.* When a bit of nerve connected with the brain or spinal cord is examined microscopically, it is found to consist of minute fibres varying in diameter from the $\frac{1}{1500}$ to the $\frac{1}{12000}$ of an inch. (See fig. 4 in Plate X.) Each nerve-fibre consists of three parts—(1) an external sheath; (2) within this the medullary sheath or white substance; and (3) in the centre a delicate fibre. (See description on Plate.) In the nerves of the sympathetic system the fibres have no white substance or external sheath. If the central portion of a nerve-fibre be traced to the brain or spinal cord, or indeed to any nerve-centre, it is found to end in the process or pole of a nerve-cell, while in the outer parts of the body it is found to end in muscle, bloodvessel, gland, skin, or sense organ. The fibres in a nerve are bound together by delicate tissue, and the structure may not be inaptly compared to that of a telegraphic cable containing numerous wires. Each original nerve-fibre is uninterruptedly continuous from its central extremity to its termination in a tissue or an organ. Each filament or trunk of nervous matter possesses its own distinct power as a peculiar endowment independently of the others bound up in the same band with it, and this individuality of each primary nerve-tubule is preserved throughout its whole course. This single power it exercises and cannot transfer, nor can another be substituted for it. If its original power and office is to convey sensation, that it will carry, and nothing else; if motor-force is its property throughout the entire length of its continuous tract, motion will be transmitted from dynamic centre to utmost extremity, provided it is normal and uninjured. On stimulating a healthy motor nerve in any part of its course muscular contractility is excited, and if we stimulate a sensitive nerve a painful or pleasant sensation will be excited, according to the stimulant employed. The other essential constituent of the nervous system is various minute bodies called *nerve-cells.* They may be spherical, ovoidal, or irregularly triangular (see fig. 5, Plate X.), and they are bound together by connective tissue, bloodvessels, and nerve-fibres, so as to form the *gray* matter seen on cutting into the brain or spinal cord. The *white* matter of these great centres consists of delicate nerve-fibres.

Gray matter is the treasury of nervous force, and the insulated and continuous white fibrous matter is the conductor and distributor of it. Conduction is threefold—(1) of sensation; (2) of voluntary motion; and (3) of reflex action. It proceeds between a centre and an extremity. The organs of sensation are either (1) the nervous system, or (2) the seats of the special senses. Every organ of sense implies two facts, (1) a sensory receptacle for receiving impressions, and (2) an arrangement by which a co-operative action and reaction may be established between them and some centre for the elaboration and use of these intimations of a change of state. The nervous system has for its special function the conveyance and conversion of sensory impressions.

The special property of a nerve-fibre or of a nerve is that it may be irritated or excited, and when this occurs some kind of change is transmitted along the nerve. The nerve is said to be *irritable* or *excitable*, and the change sent along it is called the *nerve-force.* This nerve-force travels along the fibres with a velocity of about 90 feet per second in cold-blooded animals, such as the frog, and about 200 feet per second in man and other warm-blooded creatures. A nerve may be irritated in many ways, such as by touch or pressure, by electricity, or by the chemical action on it of many substances, as, for example, common salt; but in whatever way it may be irritated, some change is sent along it to its termination, and what then occurs depends on the apparatus or structure at the end of the nerve. Thus, if the nerve end in a muscle the result will be contraction of the muscle; if in a gland, secretion; if in a bloodvessel, change in the calibre of the vessel; if in the brain, consciousness or feeling of some kind, such as heat or pain, or touch, or taste, or smell, or light, or sound; and if, as in a few fishes, in an electric organ, there will be an electric discharge. Nerves that convey impressions inwards to the centres are called *sensory* nerves; whilst those that carry impressions outwards are called *motor*, if they go to muscles; *secretory*, if they go to glands; and *vaso-motor*, if they end in bloodvessels.

The terminal organs are structures in the senses adapted to receive special kinds of stimuli. Such are the *retina* or nervous tunic in the eyeball, connected by the optic nerve with the brain, and specially susceptible to vibrations of light; the arrangements for the reception of sound waves in the ear, for sapid substances in the tongue, for odorous matters in the nose, and for contact or touch in the skin. It matters not how these terminal arrangements, or the nerves connected with them, be stimulated, the result is always the same. Thus, whether the optic nerve be stimulated by the action of light on the retina of the eye, or by pricking, cutting, pinching, or irritated by electricity, the result is not pain, but a sensation of light or of colour, the reason being that when the message carried by that particular nerve reaches the brain, it always arouses the appropriate mode of consciousness, that of light. The same law holds good of all terminal organs and of the nerves connected with them. There are also terminal arrangements where the nerves end in muscles, or in glands, or in vessels, or in electrical organs, and they are specially fitted for setting these various mechanisms in action.

The apparatus of sensation and motion—the nervous system—consists of two nerve-centres and two sets of nerves, along which there continually ply afferent and efferent messages. The *cerebro-spinal* and the *sympathetic* systems, though intimately related, are perhaps most advantageously studied apart. The former comprise the agencies of *animal*, the latter of *organic* life. The cerebro-spinal system (as its name imports) consists of (1) the *brain*, and (2) the *spinal cord.* Each of these distributes through the tissues of the body a series of nerves whose results are shown in sensation, leading to volition and action. The *sympathetic*—also called the *ganglionic*—system, consists of a chain of *ganglia*, *i.e.* masses of nerve-cells, extending from the skull to the pelvis on each side of the spinal column, and connected, mass with mass, by nervous cords. Thence there proceed ganglionated nerves to the viscera and the bloodvessels, which have their place in the chest, abdomen, and pelvis. These regulate the functions of digestion, circulation, and respiration. This system, in its entire compass,

PHYSIOLOGY.

THE BRAIN & NERVOUS SYSTEM.

Fig. 1. BRAIN & CEREBRAL NERVES

Fig. 1.

a. *Anterior lobe of cerebrum.*
b. *Middle do.*
c. *Posterior do.*
d. *Cerebellum.*
e. *Spinal cord.*
f. *Band of fibres.*
g. *Optic lobes.*
1. *Olfactory nerve.*
2. *Optic do.*
3. *Third pair.*
4. *Fourth do.*
5.5.5. *Fifth do.*
6. *Sixth do.*
7. *Facial do.*
8. *Auditory nerve.*
9. *Glosso-pharygeal nerve.*
10. *Pneumo-gastric do.*
11. *Hypo-glossal nerve.*
12. *Spinal accessory do.*
13. *Spinal nerve.*
14. *do.*

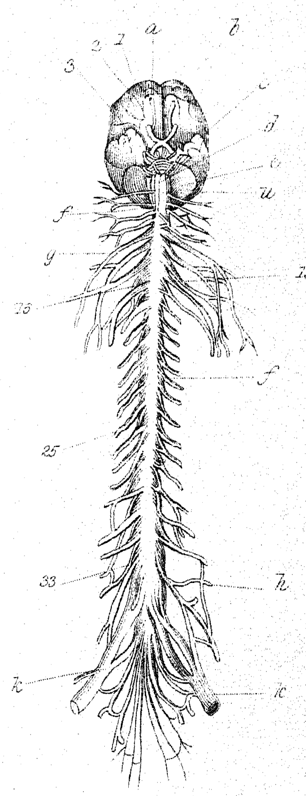


Fig. 2. BRAIN, SPINAL CORD & NERVE

Fig. 2.

a. *Brain.*
b.c.d. *Lobes of brain.*
e. *Medulla oblongata.*
f.f. *Spinal cord.*
g. *Brachial plexus.*
h. *Lumbar do.*
k. *Sacral do.*
1. *Olfactory nerve.*
2. *Optic do.*
3. *Third nerve.*
15. *Cervical nerves.*
16. " *do.*
25. *Dorsal nerves.*
33. *Lumbar do.*

Fig. 3.

a. *Cerebrum.*
b. *Cerebellum.*
c.c. *Spinal cord.*
d. *Facial nerve.*
e. *Brachial plexus.*
f. *Median nerve.*
g. *Ulnar nerve.*
h. *Cutaneous nerve.*
i. *Radial nerve.*
j. *Intercostal nerves.*
k. *Lumbar plexus.*
l. *Sacral plexus.*
m. *Tibial nerves.*
n. *Fibular nerves.*
o. *Saphenous nerves.*

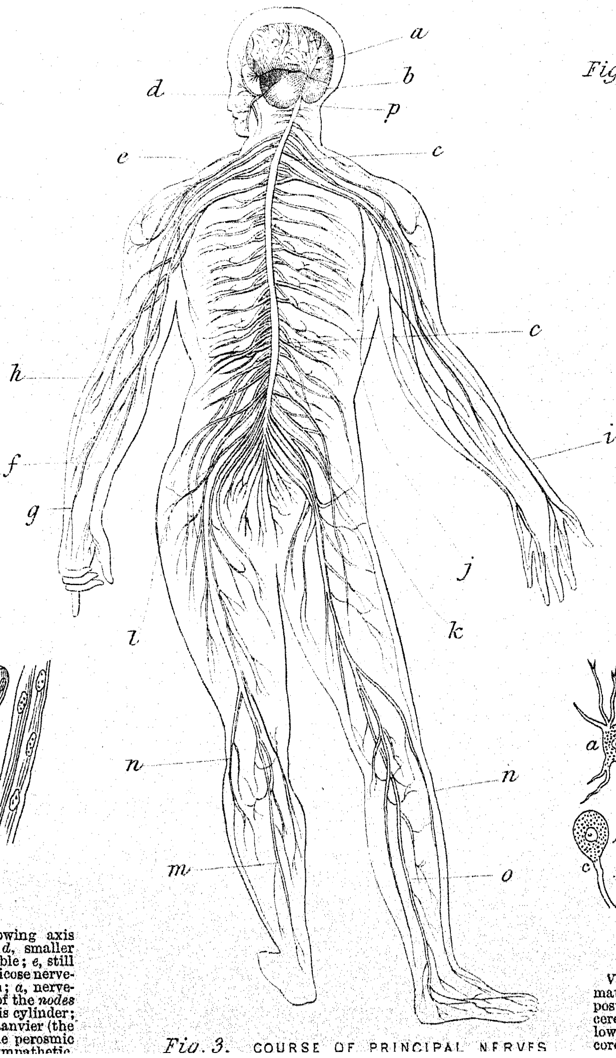
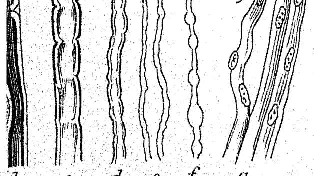


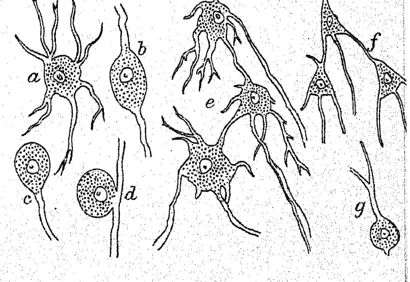
Fig. 3. COURSE OF PRINCIPAL NERVES

Fig. 4.



ves:—*c*, ordinary-sized nerve-tube, showing axis er surrounded by white substance; *d*, smaller tube, with white substance scarcely visible; *e*, still r, with no white substance visible; *f*, varicose nerve- from gray matter near surface of brain; *a*, nerve- coloured by *perosmic* acid, showing one of the *nodes* wier, or complete interruption of the axis cylinder; ve-tube showing nucleus and node of Ranvier (the ylinder is blackened by the action of the perosmic ; *g*, non-medullated nerve-tubes from sympathetic

Fig. 5.



Various forms of nerve-cells—*a*, *multipolar*, from gr matter of spinal cord; *b*, *d*, *bipolar*, from ganglia posterior roots of spinal nerves; *c*, *g*, *unipolar*, fr cerebellum; *g* shows indications of a process coming off lower end; *e*, union of three multipolar cells in spi cord; *f*, union of three cells in gray matter of brain.

includes the ganglia (1) of the great sympathetic nerve, (2) of the posterior roots of the spinal nerves, (3) of several cerebral nerves, (4) of several in the substance of some organs, and (5) of their communicating branches. The structure of all these ganglia is essentially the same, that is, they are all composed of vesicular and tubular neurine; but the fibrous portions of the ganglia are more peculiar than the vesicular parts. The *gray* matter appears in smaller vesicles in the ganglionic than in the cerebro-spinal system, and the fibres of the sympathetic system are besides smaller, softer, more transparent, darker in colour, and more uniform in material contents. One distinguishing feature of the nerves of the cerebro-spinal system is that of their pearly opaque whiteness. The cerebro-spinal axis consists of a central cord of whitish-gray colour, inclosed in a canal formed for its reception by the triangular arches, interlocked one with another, of the vertebral column. This cord is commonly known as the spinal marrow. It expands above into the brain, and gives out from its sides numerous branches of nervine tissue.

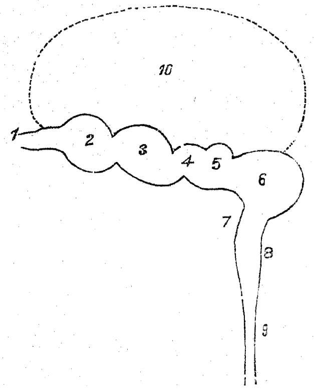


FIG. 1.—Diagram of an Ideal or Typical Brain. 1, olfactory lobes; 2, cerebrum; 3, corpus striatum; 4, optic thalamus; 5, optic lobe; 6, cerebellum; 7, pons Varolii; 8, medulla oblongata; 9, spinal cord. The dotted curve indicates the possible development of the cerebral lobes.

We present above a very simple illustrative diagram of a typical brain, such as exists in most vertebrates, but reaches its highest development in man.

The brain is a large mass of nervous matter convoluted within the wide rounded space of the cavity of the skull. It is a soft delicate organ of oval outline, and of a waxy-looking whitish-gray coloured mass, the surface of which is curiously grooved and folded with almost labyrinthine intricacy. The upper structure, the true brain or *cerebrum*, is divided by a deep central groove or fissure, passing from front to back, into two portions, called cerebral hemispheres, and each of these is regarded as having a cross-division into front, middle, and hind lobes. (Fig. 1, Plate X., represents one of these hemispheres, the brain being bisected through the central fissure.) In the position, size, and form of these lobes perfect regularity obtains. Each possesses its own distinctive anatomical character. Within its brain-case the nervous matter is enveloped in three membranes, one within the other—(1) the outer, strongest, and least vascular one, called the *dura mater;* (2) the middle, epithelic, arachnoid (*i.e.* spiderweb-like) membrane, with its specific fluid secretion; and (3) the inner, and most delicate of all, the *pia mater*, which is most abundantly supplied with bloodvessels for the nourishment of the brain.

These investing membranes dip down into and between the most minute convolutions, windings, and fissures of the brain, and form the internal lining of the various ventricles and other cavities which occur in it. The external covering (*dura mater*) of the brain is thick and strong, and it gives off certain dense processes which enter between the main divisions of the brain, and partition them off one from another. These are (1) the *falx*, *i.e.* sickle or scythe, which extends between the cerebral hemispheres, steadies them, and prevents their contents from pressing upon one another when the head is, during sleep, &c., laid on one side; (2) the *tentorium*, which forms a tent-like covering for the cerebellum; and (3) the *falx minor*, which has its place between the lobes of the cerebral hemisphere. These admirable contrivances for compacting, protecting, and nourishing the tender masses of the brain have very important offices assigned to them in the *encephalon* or brain-mass. The principal distinct masses of the entire encephalon are (1) the *cerebrum*, (2) the *cerebellum*, and (3) the *medulla oblongata.*

1. The *cerebrum*, or brain proper (figs. 2, 3), occupies the whole of the superior part of the upper cavity of the skull. Its convolutions, which fill up the front part of the brain-case completely, and overlap the cerebellum at the occiput, have a crushed or crumpled-up appearance. Each hemisphere is oval in shape, almost like an egg cut into two halves lengthwise, and separated from each other by the falx. The outer surface of the cerebrum consists of gray matter, which covers in the white neurine of the interior. This interior matter is on its under surface separated by transverse furrows into lobes. Each of its convolutions consists of a centre of white matter, with gray matter all round it. The cerebral hemispheres are those portions of the brain in which the highest and best work of the nervous system is performed, where sensation is perfected into perception and brought under the cognition of the mind.

2. The *cerebellum* (*i.e.* the little brain) occupies a space expressly formed for it by the hollow of the occipital bone. Over it the cerebrum passes, resting on the tentorium, under which, as a vaulted roof, the cerebellum is safe from pressure. It consists primarily of a vermiform process, and of two large lateral hemispheres. The external surface of the cerebellum is not, like that of the cerebrum, convoluted, but neatly folded in laminæ or thin plates, so that the largest possible amount of dynamic neurine may be packed within it in the smallest space.

3. The *medulla oblongata* gets its name from its oblong figure and the idea that it resembled marrow. It is a direct and continuous expansion into the cranium of the spinal cord. It passes from the vertebral column, through the *foramen magnum*, into the skull. As it emerges from the narrow passage it enlarges rapidly. This enlargement is due (1) to the addition to it of new bodies which complicate its structure greatly, and (2) to the deposition within its interior of large quantities of vesicular neurine. The most important and remarkable point in its character is that the nervous fibres which pass from each side of the spinal cord cross each other, those from the left going to the right, and those from the right going to the left. This explains why, when the one side of the brain is injured, the nerves on the opposite side of the body are paralyzed.

The medulla oblongata forms a most important part of the cerebro-spinal axis. The nerves which supply the larynx, the lungs, the heart, and the stomach originate in it, and evils of the utmost consequence arise from injuries to it. All the true cranial nerves take their origin in it, and the movements of the bloodvessels are due to it. A single small centre in its gray matter is noted as "the vital spot," because that if it be but touched life ceases.

Besides these greater and more important structures, there are deserving of mention several important ones—the *pons Varolii*, in front of the medulla oblongata, where the fibres of the cerebellum expand arch-like and cross each other, forming a kind of bridge named after the anatomist who first described it; the *crura cerebri*, two large rounded masses about half an inch in thickness, which become visible in front of the pons Varolii; the *corpora quadrigemina*, four hemispherical masses of nervous matter rising above and resting on the crura; the *optic thalami*, two large oval masses, consisting of vesicular tubular neurine in intimate union, into which the crura pass; the *corpora striata*, a mass of white and gray matter, into which the fibres of the optic thalami pass; the *pineal gland*, a peculiar conoid or pine-apple shaped mass of gray matter containing hard crystalline particles—it is of unknown function, and connected with the roof of the third ventricle; and the *pituitary body*, which is the termination of the funnel-like organ into which the floor of the third ventricle is transformed. Between the divergence of some parts and the convergence of others interspaces occur.

The brain is not one entire solid mass or congeries of

masses of nervous matter. There are in it two pretty large cavities, called *lateral* ventricles, and two others near the base of the brain, named respectively the third and fourth ventricles. They are not real hollows, but fissures occurring between parts contiguous, but not continuous. Fluids to prevent the agglutination of surfaces exist in these interspaces, but in a diseased state such fluids are capable of being accumulated and increased. Many minor portions of the brain—belonging to and completing the apparatus of union and co-operation—have not been noted; but enough has been given to enable the reader to comprehend the chief matters of physiological interest connected with the normal activity of the brain, especially as regards sensation and motion.

The accompanying illustration (fig. 2) of the base of the brain will enable the student to see the relative positions of the greater portion of the parts mentioned; while a reference

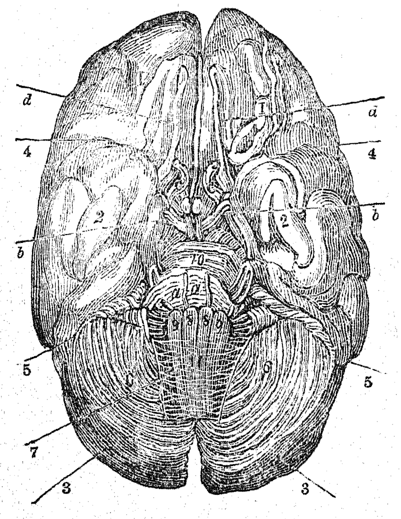


Fig. 2.—Base of the Brain. 1, anterior lobes of the cerebrum; 2, middle lobes of the cerebrum; 3, posterior lobes of the cerebrum; 4, fissure separating the anterior from the middle lobes; 5, situation of the superficial excavation forming the boundary between the middle and the posterior lobes; 6, the two hemispheres of the cerebellum, composed of flattened laminæ or layers; 7, the medulla oblongata, which in this position of the brain rests upon and covers the vermiform process; 8, corpora pyramidalia; 9, corpora olivaria; 10, tuber annulare, or pons Varolii; 11, decussation of the corpora pyramidalia; *a, b, c, d,* cerebral nerves.

to Plate X., in which the cerebro-spinal axis is represented in figs. 1, 2, and 3, with the more important of the sensory nerves and the more essential centres of the nervous system, will be found far more instructive and intelligible than a large amount of merely verbal description.

The spinal cord is a longitudinal mass of fibrous and vesicular mucous matter, encased in the bony cavity of the vertebral column, and extending from the *foramen magnum* to the second lumbar vertebra, where it tapers off into a filament.

The bony structure of the spine has been already described (p. 46), so that it will be sufficient for us here to recall the three facts: (1) that it is a bony case, elastic and mobile, on account of its numerous joints strong enough to bear weight and able to resist great violence; (2) that by its curved form and elastic plates it is pretty well protected against concussions; and (3) that it is preserved from friction by a lining of elastic matter. These arrangements are intended to secure the integrity of the spinal cord. Within the vertebral column the dura mater, the arachnoid membrane, and the pia mater, which form the enwrapping envelope of the brain, provide an internal covering called the vertebral sheath, not to the vertebræ, but to the cord which it surrounds and protects. The vertebræ contain between their inner periosteum and this sheath a layer of fatty and areolar tissue which acts as an internal cushion between the bones and the sheath. Between the dura and the pia mater, the arachnoid membrane secretes its peculiar watery fluid, and this furnishes a moderate and uniform pressure for the spinal cord. The cord is slung and suspended in the centre of this sheath by elastic threads proceeding from each side of the vertebral sheath; various teeth-like processes are attached to, and hold and steady the spinal cord. The denticulated ligament, from which these lateral supports proceed, preserves the precious medullary treasure in its proper place easily, and as the sheath terminates in a number of strong elastic filaments, which are lashed, as it were, to the *os coccyx*, the cord is provided with vertical stays as well. Arrangement has also been made for the maintenance of uniformity of pressure by providing little bags for the reception, on occasion of any local or general overflow, of arachnoid fluid, just where each spinal nerve is about to leave the vertebral canal.

The spinal cord is a mass of nervous matter of a somewhat compressed cylindrical shape, not of the same thickness throughout its whole length, but enlarging and diminishing according to the importance and requirements of the nerves it gives off during its course from the cervical to the lumbar vertebræ. The cord itself is a double organ, composed of two symmetrical halves—each half forming a complete nervous centre, and carrying on its own specific functions. Each half is divided lengthwise by two fissures into three parts: (1) anterior, (2) lateral, and (3) posterior; while a commissure or uniting band of white fibres, running across the cord, connects the corresponding halves one with the other. Down through the centre of the cord, a narrow canal lined with epithelial matter passes, traversing its entire length from the fourth ventricle of the brain to the termination at the *cauda equina.* Looked at externally, the cord presents the appearance of a grayish-white, soft, fibrous, neurine matter. When, however, a transverse section is made, each half is seen to contain two substances—a white substance in the outward part, and a gray, reddish-tinged matter in the centre. This latter matter is definite, yet peculiar in the manner of its disposition. It takes a crescent or semi-lunar shape, with the concave side turned outward, thus) - (, in each half, and the convex sides are joined together by filaments which contain the central canal. The ends of the crescent are called *cornua* (or horns), those to the front being called the anterior, and those towards the back the posterior. It is not easy to describe in any popular way the precise origin of the spinal nerves and the complex communications of the roots of the nerve-fibres with the different constituent parts of the spinal cord. Each spinal nerve has an *interior* and a *posterior* root. These roots issue by delicate filaments from the lateral fissures on each side of the surface of the cord. After they have pierced through the vertebral sheath, the fibres which had been separate one from the other unite to form special trunks, but shortly thereafter subdivide and ramify along their specially assigned courses. The fibres which spring from the posterior root are *sensory*, and those from the anterior are *volitionary* or motor. Every primitive fibre of the root of such a nerve must have a connection with the centre from which it originates, and therefore representatives of all the separate nerves must be contained in the cerebro-spinal axis. These must be densely massed and completely interlaced, but into the question of how these primitive fibres of the spinal nerves ascend to the brain or depute to other tissues the communications which require to be held with it, cannot be profitably considered and discussed in a merely popular, unprofessional, and initiatory compendium. They take their issue in an orderly and distinct series; they distribute themselves to all parts of the body, and there is no tissue in it to which they do not contribute their fibres or in which they do not exercise their offices.

Those parts of the nervous centre constituting the brain give off several nervous trunks. These are arranged in pairs, and are called cranial or cerebral nerves. The greater part of these do not, however, pass forth directly from the brain itself, but proceed mediately from the medulla oblongata, the spinal cord, &c., in an order and number which are in part differently named and numbered by the physiologists of this and of other countries. The division into twelve may be adopted here as that which affords the most distinct classification. (See fig. 1, Plate X).

The spinal nerves are symmetrical. There are thirty-one pairs of them. Each pair contains two roots—is, in fact, a compound nerve—and performs a double function. The spinal nerves, given off as they are in two lateral series from each

half of the spinal cord, pass out of the vertebral canal by openings between the vertebræ, which are named vertebral *foramina* (openings). Thereafter they divide and divaricate until, in the minuteness of their ramifications, they inosculate with the muscles and reach every part of the skin. These spinal nerves receive their names from the vertebræ under which they issue. (See Plate X., figs. 2 and 3.) There are (1) eight cervical, (2) twelve dorsal, (3) five lumbar, and (4) six sacral nerves on each side. The anterior root of each spinal nerve is motor or *efferent*, and the posterior sensory, sensitive, or *afferent*. These sensory roots have ganglia through which the motor fibres pass. The sensitive nerves pass onwards chiefly to the skin, where impressions impinging on them may be transmitted to the nervous centres, there to be received and appreciated; while the motor nerves, for the most part, attach themselves to and interpenetrate the muscles, which, being instruments of motion, require the stimulant of nervous force to be transmitted and applied to them. If an injury occur to one of these spinal nerves immediately on its leaving the vertebral column, entire paralysis of the nerve supervenes—motion and sensation are both destroyed. If motor fibres alone are hurt, loss of power of movement occurs—sensation remains. If only the sensory fibres suffer lesion, incapacity to feel is produced, but the power of motion is not destroyed. If the spine is broken, or materially injured, those parts of the body which are below the seat of the injury lose their power of sensation and voluntary movement; but if the nerves of sensation be stimulated by appropriate excitation, the afferent nerves will communicate the unconsciously received impression to some centre where an efferent nerve may be found, and the motor impulse natural to the latter will be sent onward to the seat of the excitation. This is called reflex action. If, however, the spinal cord were severed lengthwise down its main fissure, sensation would be destroyed throughout the body and limbs.

CRANIAL OR CEREBRAL NERVES.

No.	Name.	Origin.	Distribution.	Function.
1.	Olfactory, ...	Corpora striata, ...	The mucous membrane of the nose,	Sensory, *smell.*
2.	Optic, ...	Optic thalami and tubercles, . .	The internal surface of the eye, forming the retina, . . .	Sensory, *sight.*
3.	Motors oculi (*movers of the eye*), ...	Inner side of the crura cerebri, . .	The muscles which move the eye-ball, ...	Motor.
4.	Trochlear (*pulley-like*) or pathetic, . . .	Corpora quadrigemina, ...	The superior oblique muscle of the eye, ...	Motor.
5.	Trigeminal or trifacial,	Medulla oblongata, near pons Varolii,	Skin of the face, muscles of the jaw, and front of tongue, .	Motor and sensory, *taste.*
6.	Abductor, ...	Medulla oblongata and the fourth ventricle, ...	External rectus muscle of the eye,	Motor.
7.	Facial (*portio dura*),	Medulla oblongata and crus cerebelli, ...	Muscles of the face, external ear, parts of the neck, ...	Motor.
8.	Auditory (*portio mollis*),	Medulla oblongata, ...	The internal parts of the ear, . .	Sensory, *hearing.*
9.	Glossopharyngeal (*tongue and throat*), . . .	Medulla oblongata, ...	Tympanum, carotid artery, throat, tonsils, and side and base of tongue, ...	Motor and sensory, *taste.*
10.	Pneumogastric (*lung and stomach*), . .	Medulla oblongata, ...	Throat, lungs, liver, stomach, and heart, ...	Sensory and motor.
11.	Hypoglossal (*lingual*), .	Medulla oblongata, ...	The muscles of the tongue, . .	Motor.
12.	Accessory, ...	The sides of the spinal cord between the dorsal nerves, ...	Behind internal jugular vein, sterno-mastoideus, and trapezius or muscles of the shoulder, .	Motor.

It will readily be observed that 1, 2, and 8 are nerves of special sensation; that 3, 4, 6, 7, 11, and 12 are nerves of motion; and 5, 9, and 10 are compound nerves. As 7 and 8 leave the brain together they are sometimes reckoned one pair; so because 9, 10, and 11 pass from the skull through the same orifice they are often counted as one. The accompanying Plate will distinctly show, if carefully studied along with the above-given table, the origin, course, and relation of the different nerves. In it 12, 13, and 14 are (in accordance with a minute anatomical dissection) shown as separate, though, as stated in the text, they may be followed to, and regarded as having, a common origin.

The main trunk of the *sympathetic nervous system* proceeds in a double parallel chain of thirty ganglia from the head, along the neck, the thorax, and the abdomen, to the os coccyx on each side of the front of the spine. Its roots are formed by numerous filaments derived from most of the cerebral and all the spinal nerves. In the region of the head there are four ganglia on each side, all intimately related to the trifacial nerve. They are (1) the ophthalmic, (2) the sphæno-palatine, (3) the otic, and (4) the sub-maxillary ganglia, each engaged in regulating processes necessary to cephalic soundness and usefulness. It exhibits a double row of ganglia, which in the chest and abdomen appear at intervals between the three cervical, eleven thoracic, four lumbar, and five sacral vertebræ, and from these it gives off a large number of branches, which are often congregated into ganglia, and help to supply the viscera, many blood-vessels, glands, and other textures with neurine influence. The ganglionic enlargements of the nerves are due to the addition of ganglionic globules or corpuscles to their nerve-fibre, each globule possessing a proper sheath, and probably a definite physiological function.

The sympathetic system includes (1) the pre-vertebral ganglia; (2) the isolated ganglia of the viscera, including (*a*) the cardiac plexus, (*b*) the epigastric or abdominal plexus, and (*c*) the hypogastric or pelvic plexus; (3) the ganglia on the posterior roots of the spinal nerves. The connection between the sympathetic ganglia and the cerebro-spinal nerves is brought about by four small fibres, two gray uniting the anterior and posterior root of the spinal nerve to each ganglion, and two white, also communicating similarly with the root of the spinal nerve. These ganglia evidently receive both sentient and motor power, and thus by gelatinous masses of nerve-fibre they carry through all their communicating branches the nervine influence, so that, wherever they go, in their progress through the organs and tissues of the body, the sympathetic nerves contain intermingled with them some spinal and cerebral nerve force, while all cerebral and spinal nerves also hold within them some sympathetic nervous agency. The cerebro-spinal nerve system is singularly concentrated and consolidated. The ganglionic system is just as strangely diffused and decentralized. The independence of the latter is shown by the fact that the parts supplied with nerve force by it continue their operations for a time though the connection between them and the cerebro-spinal system is severed, while the interdependence of each system (from which this system gets its name of sympathetic) is proved, not only by the intermingling of fibre, but also by their exercise of a certain amount of co-influence one on the other. Though the *vaso-motor* nerves do not belong to the cerebro-spinal cycle, yet the latter is undoubtedly

a centre whence vaso-motor power is derived. It is free, in ordinary circumstances, to carry on in undelegated automatic fashion the great functions of organic life in the individual, but yet dependent on the central organized system of nervous energy for its supply of that power which enables the frame to breathe, to digest, and to keep up the systemic circulation of the blood. That more concentrated and highly developed nerve-system, which brings the individual life into the relations of existence, industry, perception, and sociality, is also free to carry on the requisite duties of all life's relations without the incessant care, anxiety, and attention which would be necessary if every organic function were kept going by volition, and there was not a great and almost involuntary institution in the sympathetic nerve-system for conducting the ordinary processes of bodily life. It is evident that a complex nervous machinery such as we have endeavoured to describe, bringing into relation with the great central sentiency of the brain the whole superficial extent, external and internal, of the human frame, and capable of issuing commands over an area equally extensive, must have many intricate inter-relations which lie beyond the scope of popular exposition. Enough has, however, been said to show how important it must be to keep the entire nervine centres and their ramifications in perfect healthy activity, and how wonderful the nature is which possesses so complete and thorough a system of intercommunication.

BOOK-KEEPING.—CHAPTER IV.

REGISTRATION OF TRANSACTIONS—WASTE BOOK AND DAY BOOK: THEIR USES AND FORMS.

THERE can be no doubt that the precise and exact registration of commercial transactions is of prime importance. In some mercantile establishments arrangements are made for the general recording of every trade transaction that goes on during each day—sales, purchases, cash received and cash paid, bills accepted and settled, transfers of stock from hand to hand, proposals made and proposals received, expenses incurred, losses announced, and any other facts connected with the carrying on of the business—including engagement or dismissal of assistants, statements of terms offered and accepted, wages paid, duties assigned, and so on; in fact a complete diary of occurrences connected with the business. In such a book, any one who has charge of any branch, who has been intrusted with the care of any special duty, or who has entered into, progressed with, or concluded any transaction, is required to make immediate note, so that it furnishes really a series of memoranda of all that has gone on under any responsible agent of the establishment. It requires, therefore, to be always ready and at hand for instantaneous use. This is sometimes called the Transaction Book, the Diary or the Waste Book, but, whatever its name, its nature is to be a history of the business transacted day by day.

In other establishments a different system prevails, although the end sought and obtained is the same. A daily personal note-book is put into the hands of each employee, and in this he is expected to enter, at the moment, each transaction effected in his department, so as to be able to give immediate and exact account of all that he has done, and to provide at once a means of knowing how the affairs under his charge are going on. These note-books are not only checks but counter checks, because they record not only all stock received into each department, but all the changes which take place in it by removal, sale, or otherwise, and all the results of such changes in cash sales, credit sales, transferences, &c., of which the note-books of some other department also contain corresponding registration.

The entries in these books afford the rough materials out of which the items of systematic accounting are selected. Many of the entries in such books may be of only a temporary nature, containing a simple narrative of what has been done, and may even be, from want of capacity in the recorder, too immethodical for any use except for reference to or authentication of transactions. Commodities bought, sold, received, delivered, bargained for, offered for disposal; contracts made or proposed, offers accepted or rejected; notes of terms of purchase and payment, of marks, weight, measure, quality, &c., may all be entered into such a book (or books) just in the order of their occurrence in time, and with no clear relation to what has gone before or will come after. Many of the entries may be of a trifling sort—the sending of goods on sight, which may have been almost immediately returned; goods supplied to persons whose custom is uncertain, or for whom, on other grounds, it may not be thought advisable to open any account, or matters referring merely to the interchange of stock between departments. Hence it is that such contributory books, as they might be called, which furnish the materials for the distinct and definite entries of the Day Book, Cash Book, Bill Book, &c., are often rightly enough called Waste Books, not because they are useless or unnecessary, but because that when all that is specifically requisite for the proper registration of business transactions has been selected from them and methodized into other distinctly business books, they do not need to be particularly kept, and may be, like everything else which can be of no further service, discarded as waste. Of course the daily examination of such books furnishes matter to be dealt with in other books, and a periodical review of such books will prevent the overlooking of any important outstanding item, anything relating to which may be carried forward by note of reference or extract into any other book to which it may seem desirable to transfer it.

Specific business book-keeping requires a distinct, trustworthy, properly arranged, and rightly methodized style of record, in which business transactions alone, in their double form of stock and cash, may be distinctly registered in such a mode as may most easily be referred to when required. This necessitates the use of a special business Day Book, which is, however, nowadays practically restricted to an account of all such sales as are effected on credit day by day.

A Day Book, as its name implies, is one in which the business transactions of the day are set down regularly in the order in which they occur. It is the chronological history of the business. It notes regarding every transaction, (1) the date; (2) the parties—care being especially taken to be correct in the names, designations, and addresses of the same; (3) the denominations, quantities, prices (and if necessary the qualities) of goods; (4) the terms of payment; and (5) any other condition or circumstance requiring record. Such entries ought to be made in a precise, comprehensive, simple style, leaving nothing unexplained which is essential to an exact knowledge of each transaction. This, it will be seen, is necessary, that a tradesman or merchant may be able either to make out accounts for his customers correctly, or to check off those presented to him by those with whom he deals. Of course cash sales are entered into the Cash Book, which is really a sort of Cash Day Book, and such entries do not appear in the Day Book at all; but any cash received from credit purchasers or payments made to parties from whom goods on credit have been received, make their appearance in the Day Book. At the close of each day these sums are journalized, if a journal is kept; and if so, the particular personal account to which they are to be posted is indicated, and a mark put on the margin of the Day Book to show that this has been done.

In commencing a business Day Book the first entry consists of an inventory. This comprises two distinct parts—1, the merchant's *Assets*, *i.e.* (1) the *money* he possesses (or places in and allocates to the carrying on of this particular business); (2) the goods on hand; (3) the debts due to him at date; and (4) any other kind of property to be used in or employed for the carrying on of the business, *e.g.* machinery, horses, vans, workshop or warehouse; and 2, the merchant's *Liabilities*, *i.e.* debts due to others, liens, mortgages, &c., on any property. The difference between these two constitutes his *Net Stock*, that which forms the precise amount of the capital invested in the business and is to be traded with. Of all that affects, *i.e.* increases or diminishes, this net stock, whatever its nature, the merchant's books ought to present an exact record. If this is not done, the very object of book-keeping would be frustrated, and when a balance came to be struck the absolute extent to which, so far as his business was concerned, the merchant was richer or poorer, *i.e.* how much his net stock had been augmented or lessened in the course of trading, would not be ascertainable. As to the *form* of entries

in the Day Book, we may state that it is usual, on the top of each page (which should bear on its outer corner its progressive number), that the place of business, the month, and the year should be written in a large, bold, legible style of penmanship above a distinctly ruled head-line. The only other ruling required is on the left-hand columns for the month and day, and, on the right, single money columns. We subjoin a specimen, which may be copied either on a slip of paper ruled to pattern by the student, or on a sheet of similarly ruled paper, which may readily be purchased:—

REMMINGTON, *June*, 1888.

			£	s.	d.
		Inventory of the estate of William Milbrowne—taken at this date, 1st June, 1888.			
June	1	Cash in hand [as per Balance-sheet Ledger, f. 792],	963	17	$7\frac{1}{4}$
		Stock in trade (or goods in hand) [as per Stock Book balance, page 304], ...	336	10	$1\frac{1}{4}$
			1300	7	$8\frac{1}{2}$
"	3	Debts due by me [as per Balance-sheet, f. 792], .	427	7	6
		Net stock, ...	873	0	$2\frac{1}{2}$
"	3	Bill Receivable—Capt. George Stansfield of Holt Hall, Cheshire, paid, ...	580	0	0
"	4	Sold Richard Grainger, 23 Eighborough Street, Stanmore, 10 pieces tweed, 18 yards each, at 2*s.* 6*d.*, ... £22 10 150 yards broadcloth, 6*s.* 6*d.* per yard, 48 15	71	5	0
		Sold Benjamin Preston, 193 Aston Manor Road, Rochdale, 12 pieces tweed, 10 yards each, at 2*s.* 10*d.* per yard, . £17 0 0 4 pieces broadcloth, 16 yards, at 4*s.* per yard, . . 12 16 0 £29 16 0			
		Received in cash £9 16*s.* bill three months (due 7th September), . . 20 0 0	20	0	0
"	5	Bill payable, Andrew Moorfields, 7 Dron Place, Holmley, discharged £347, ...	347	0	0

Some book-keepers prefer a more distinct method of dating, and having given at the top of the page the name of the month, look upon it as unnecessary to do more than place the date in the centre of the line which divides and individualizes the record of each transaction. The last entry would then take the following form:—

June 5.

J	Bill payable—Andrew Moorfields, 7 Dron Place, Holmley, discharged, ...	£347	0	0

This method has the merits of economy of writing and of distinctness, and besides it leaves the left-hand margin free for the placing before each entry the letter *J.*, as it is *Journalized.*

Where a business is large and its departments or ramifications are numerous, the Day Book is frequently subdivided so as to be either (1) only a sales book; (2) several sales books, classified sometimes in one way, sometimes in another, *e.g.* into departments, as silks, merinos, ribbons, &c., tweeds, broads, and so on; into branches I., II., III., &c., in which entries are made of all goods in these departments or branches *sold on credit*, and are noted and described so as to be readily debited to the respective accounts of the proper parties. Such entries would run simply

June 5.

To J. Herbert Unwin, 17 Castle Street, Drem.
5 pieces broadcloth, 17 yards each, at 5*s.* 6*d.* per yard, ... £23 7 6

"

To W. A. Osborne, 179 Elm Row, Fossway.
50 pieces serge (131^d) 14 yards each, 1*s.* $0\frac{1}{2}$*d.* per yard, ... £10 1 $5\frac{1}{2}$

Each entry would, of course, be a Dr. one, which could be transferred at once to the personal accounts in the ledger; but each one would also become a Cr. entry in the accounts, for instance, of broadcloth and of serge, or according to the headings and divisions adopted of stock in the Ledger. This process is formulated into the rule "Debit the personal, credit the goods account." In extensive concerns a Stock Ledger is kept with regular Dr. and Cr. of all purchases and sales, so that stock on hand of any sort of goods may be known at once and a review may be made of it at any time. In other cases the stock is placed in charge of a special individual, and the stock-clerk must attend to debit stock with all goods delivered, and to credit it with all goods sold or sent out.

GEOMETRY.—CHAPTER IV.

BISECTION OF ANGLES—STRAIGHT LINES—PERPENDICULARS.

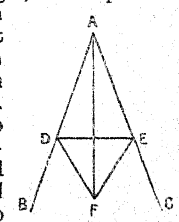
WE shall presume that now our readers have become acquainted with "the logic of geometry," and are able to follow the course of thought presented in a demonstration on its being placed before them in a plain though condensed manner. We shall therefore from this point gradually abbreviate our elucidatory remarks, as well as shorten (when the steps are very simple) the phraseology of demonstration. In order also that geometrical thought, rather than routine, may be cultivated, we shall introduce figures other than those commonly found in Euclid's Elements, and forms of proof illustrated by them which vary the mode of reasoning to some extent, and give some sense of change during our progress through the propositions.

Geometry is not only theoretical, it is practical as well. Euclid supplies us with theorems to be proved and problems to be done. But what he requires us to do is to be effected upon distinct principles satisfactory to reason. We frequently find ourselves called upon to divide an angle into definite parts. Euclid undertakes to show us how this can be effected with infallible accuracy, and he puts it before us in the following

PROPOSITION IX. PROBLEM.

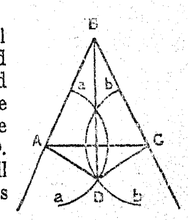
To bisect a given rectilineal angle; that is, to divide it into two equal angles.

Let B A C be the given rectilineal angle; it is required to divide B A C into two equal angles. In A B take any point D, and (by I. 3) cut off in A C, A E equal to A D. Join D E, and on the side of it remote from A, describe the equilateral triangle D F E. Join A F. We have now the two triangles D A F, E A F, precisely fulfilling the conditions of equality defined in I. 4; hence the angle D A F is equal to the angle E A F. But these two together constitute the angle B A C, and it has thus been divided into two equal angles. Q.E.F.



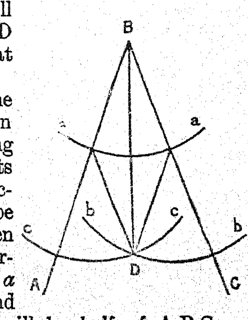
J. M. Wilson supplies another neat and accurate demonstration of this problem.

A B C is the given angle. Equal lengths B A, B C, being taken in it and A C joined, then with centre A, and any radius greater than half A C, describe a circle *a a*. Describe a similar circle *b b* from C. These shall intersect in D. Join A D, C D, and B D, and B D shall bisect the angle A B C; for the triangles A B D and C B D are (by I. 4) equal.



We here show another form of working out this problem. It is one which on examination will be found to yield proof that A B D equals C B D, and hence that A B C is bisected.

In this construction, from the point B, with any radius less than half A B, describe a circle cutting the sides A B, B C, in the points *a, a;* from these points respectively, with the radius *a*B, describe the circles *b b* and *c c;* and then join the point D, where these circles intersect one another, to *a* and *a*. Then will D *a* B and D *a* B equal each other; each will be half of A B C, and therefore A B C will be bisected.



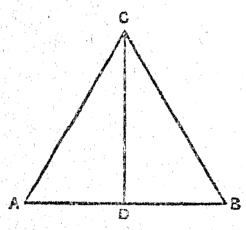
By this proposition we can bisect any given angle into any number of parts having the power of 2, as 4, 8, 16, 32, &c., as well as $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, &c., but we cannot by the constructions in plane geometry allowed by Euclid, trisect *any* given angle, though it is possible to divide a right angle into three equal parts.

If the student remembers that in the first proposition he learned to describe an equilateral triangle upon a given finite straight line, it will help him to understand how to work this second problem regarding straight lines, which appears in Euclid, Book I., as

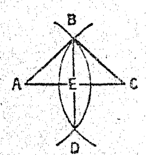
Proposition X. Problem.

To bisect a given finite straight line; that is, to divide it into two equal parts.

Let A B be the given finite straight line. It is required to divide A B into two equal parts. Upon either side of A B describe the equilateral triangle A C B (I. 1). Bisect the angle A C B by the straight line C D, meeting A B at D (I. 9). A B shall be bisected in the point D. By construction, A C is equal to C B, and C D is common to the two triangles A C D, B C D, and therefore (by I. 4) the angles are equal in every respect. Hence the base, *i.e.* the straight line, A D is equal to the base, *i.e.* the straight line, B D, and these are the two parts of A B. Therefore, A B has been bisected into two equal parts. Q.E.F.



It is evident that, by a construction such as that here exhibited, if with A as centre we take on A C any radius greater than half A C and describe a circle, and repeat the same process with C as centre, we shall have two circles intersecting at B and D. On joining B D it will be found that the line B D cuts A C in E. When A B and B C are joined, we have an angle A B C bisected by B E, and the two triangles A B E, C B E, are equal in every respect (I. 4). Wherefore their bases A E and C E are respectively equal one to another, and they are the straight line A C. The finite straight line may, by successive similar bisections, be divided into 4, 8, 16, &c., equal parts, or into $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, &c.

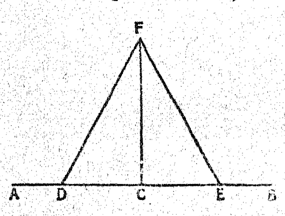


Proposition XI. Problem.

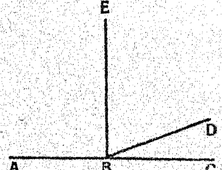
To draw a straight line at right angles to a given straight line, from a given point in the same.

The third proposition regarding straight lines is given by Euclid as a problem—viz., A B given straight line, C given point. Required to draw from C, at right angles to A B, a straight line.

In the part A C, take any point D, and make C E in the part C B equal to C D (I. 3). Upon D E describe the equilateral triangle D F E (I. 1) and join C F. C F is at right angles with A B. By I. 8 the angle D C F equals the angle E C F, and they are adjacent angles, but equal adjacent angles are right angles (def. 10), and the line C F, common to each, is a straight line, and it is drawn from the point C at right angles to A B. Q.E.F.



Corollary 1. By help of this problem, it may be proved that two straight lines cannot have a common segment. For, if it be possible, let the segment A B be common to the two straight lines A B C, A B D, and from the point B draw B E at right angles to A B (as in this proposition). Then, because A B C is a straight line, A B E is equal to E B C. Similarly, A B E equals E B D. But angle A B E equals E B C, so that the angle E B D equals E B C (Axiom 1), the less to the greater, which is impossible. Hence, two straight lines cannot have a common segment.



This corollary is in point of fact assumed in the demonstration of I. 4, in which it is affirmed (see p. 138) that if A coincides with D, and B C with D E, the point B shall coincide with the point E, which it would not necessarily do if two straight lines could have a common segment.

The proof of this corollary, which was added by Simson as "necessary to Prop. 11, Book I., and otherwise," is scarcely quite sound, because we have not yet been shown how to draw a straight line from a point at the extremity of another straight line. It might be regarded as deducible from the very definition of a straight line, for if a straight line is the shortest distance between *two* points, it cannot be the shortest distance between *three* points.

Corollary 2. When one straight line is the shortest that can be drawn from a point to another straight line, these two straight lines are perpendicular to one another. In actual practice such straight lines are drawn by the aid of the square.

Corollary 3. Only one perpendicular can be drawn from a given point to a given line.

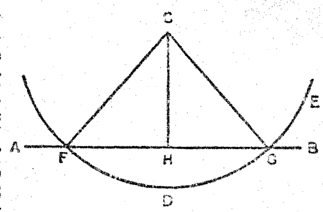
The Euclidean demonstration will not apply if the point C is given at the extremity of the line. In that case, however, by Postulate 2, the line may be produced, and then his construction can be proceeded with.

We cannot always have our point given us *in* the same straight line. Euclid saw this, and provided us with another proposition to meet that objection. It appears as

Proposition XII. Problem.

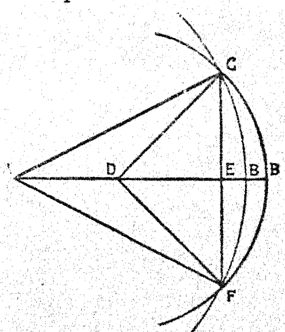
To draw a straight line perpendicular to a given straight line of an unlimited length, from a given point without it.

A B given line, C point. Required a straight line drawn from C at right angles to A B. Take any point D on the other side of A B from C. From centre C, with distance C D, describe the circle E G F cutting A B, which being indefinite can be produced if necessary, in F and G. Bisect F G in H (I. 10), and join C H, C F, C G; C H will be at right angles with A B. F H and G H equal each other (by construction), and H C is common to the triangles F H C, G H C, so that the triangles are equal, and their adjacent angles are equal, wherefore their common straight line is a perpendicular, and thus from the point C a perpendicular C H has been drawn to the given straight line A B. Q.E.F.



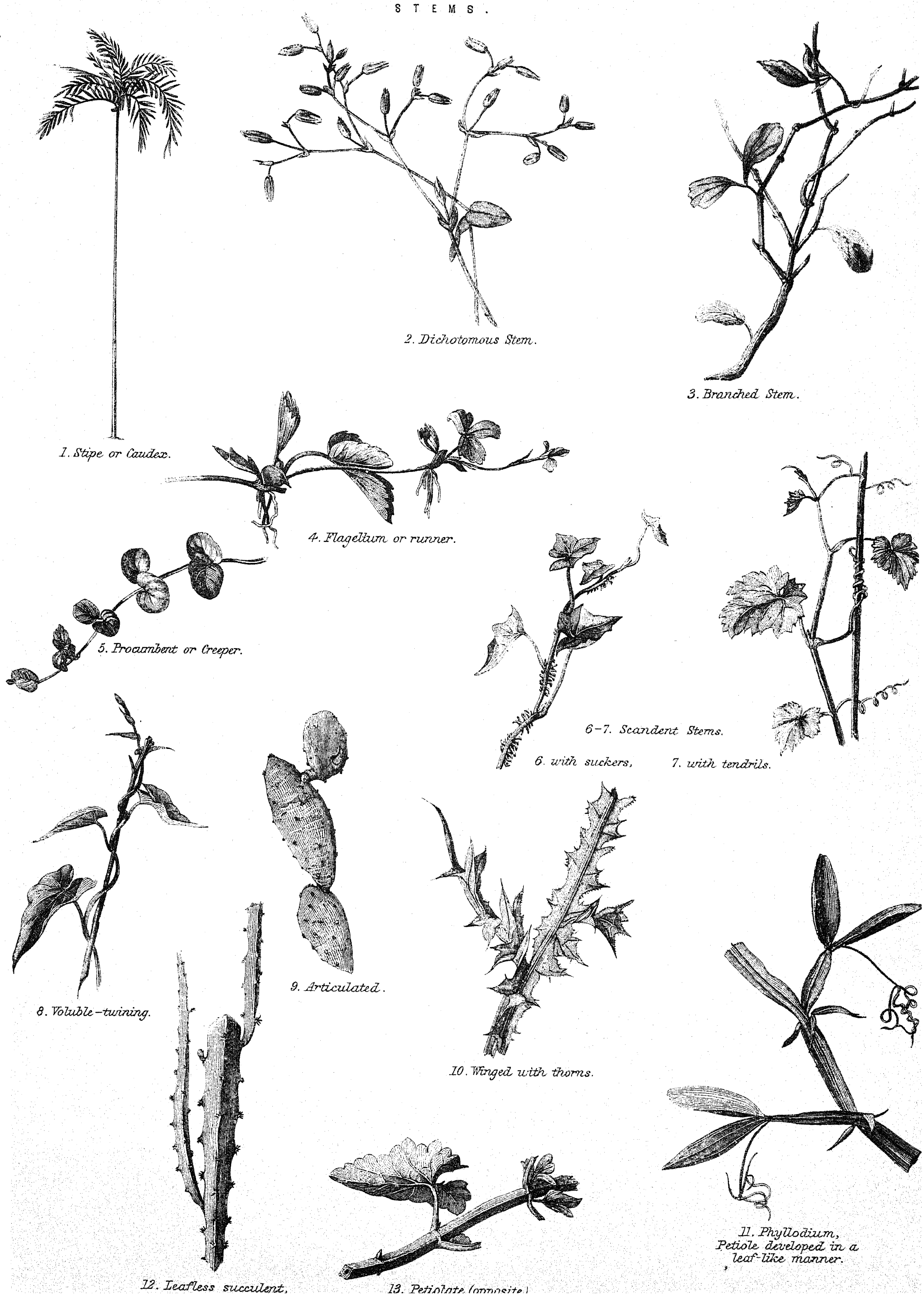
If the given straight line had not been persistently produced it might not have met the circle, and the construction could not have been effected. It requires to be noted that without fulfilling the third postulate and drawing the line C D as radius, we have had no warrant granted us to describe the circle F D E.

This problem may be very elegantly and conclusively worked out thus:—In A B take any two points A and B, and from these as centres with radii A C, B C, describe circles cutting one another a second time in F. Join C F, and let C F cut A B in E. Then A C F, B C F, will each be isosceles triangles upon the same base C F, and the line A B which joins their vertices, bisects the base at right angles; that is, C E is at right angles to A B. Wherefore, from the given point C, without the given straight line A B, a straight line C E has been drawn at right angles to A B. Q.E.F.



BOTANY.

STEMS.



1. Stipe or Caudex.

2. Dichotomous Stem.

3. Branched Stem.

4. Flagellum or runner.

5. Procumbent or Creeper.

6–7. Scandent Stems. 6. with suckers, 7. with tendrils.

8. Voluble–twining.

9. Articulated.

10. Winged with thorns.

11. Phyllodium, Petiole developed in a leaf-like manner.

12. Leafless succulent.

13. Petiolate (opposite).

This method is peculiarly useful when the point C falls (or is given) very near the edge of the paper upon which the problem (practically) requires to be worked. The drawing of a right line, at right angles to another right line, from a given point without it, is technically called "letting fall a perpendicular."

BOTANY.—CHAPTER IV.

STEMS: NAMED, CLASSIFIED, AND DESCRIBED—THALLOGENS—ACROGENS—ENDOGENS—EXOGENS.

That part of a plant which rises out of the ground receives in scientific language the name of *stem* or *caulome*. The botanist classifies and describes the different kinds of stems. The root is the "descending axis" of a plant, the stem is the ascending one. It is formed by the upward prolongation of the plumule of the embryo. It differs from the radicle in having no cap-like envelope at its growing end; for the most part it seeks the light, and generally develops in the air. The stem supports the various organs of each plant, serves as a medium for the conveyance of the vegetable sap, which the root has absorbed from the earth, to every other part, and becomes in many cases the depository of their special secretions.

Plants have from the earliest period—from observations of the nature, the duration, and the method of the branching of their stems—been divided into herbs, shrubs, and trees. The distinctions between these may be stated here. A tree is perennial, and rises from the ground by a single trunk; a shrub is also perennial, but it breaks the ground in a number of adjacent trunks. Both agree in having hard woody stems. An herb is soft and green, and its stem dies away after its fruit has been perfected—it may be after one season, as the lily; or after two, like the common cabbage. The herb is therefore obviously distinct from the other two. The tree and the shrub do not depend for their difference on their size, although that quality generally accompanies the other difference, but upon the arrangement of the stem. The common holly, for example, is a tree, although it is seldom seen of any considerable size; the barberry is a well-known example of a shrub.

We may distinguish the following kinds of stems:—(1) The *trunk* is the name given to the stem of timber trees, the boughs, the branches, and the twigs being all comprised as parts of it; (2) the *caudex*, of shrubs; (3) the *stipe*, of such plants as palms and ferns; (4) the *culm* or *haulm*, of grasses, reeds, and similar plants; (5) the *caulis*, in herbs. The most important function of the trunk (including its radicles and smallest twigs) is to convey nourishment to the foliage, flowers, and fruit. To carry on this function its structure is, with great care and delicacy, adapted. The particular

Fig. 1.

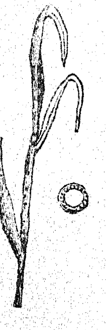


Fig. 2.

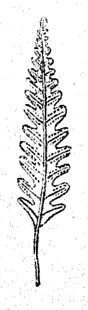


Fig. 3.

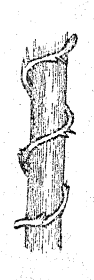
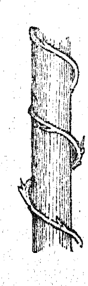


Fig. 4.



kind of stem styled a *culm* (fig. 1) presents a smooth hard outside, scarcely separate enough to be called a cuticle; within, it is cellular, contains vessels, and at certain distances it presents knots, where the upper part of the stem ceases, to be received into a sheathing leaf growing up from the lower. The straw (*culm*) is in general *knotted*, the joinings being enlarged; sometimes *jointed*, the joinings being small; sometimes *geniculate*, *i.e.* knee-jointed, when the joined parts bend to alternate sides. The leaves of *acrogens* or ferns (fig. 2) are denominated *fronds*, and the petioles or stems are called *stipes*. The frond differs from a leaf in this, besides other obvious marks which exist in its minute texture, that it bears the fructification upon its under surface.

It has been stated in Chapter III. that sometimes, from some peculiarity of form or function, stems do not push their way into the upper air, and so—under the various names of tubers, corms, rhizomes, pseudo-bulbs, &c.—are spoken of as roots. Writing, as we are, for general rather than scientific readers, we have explained (see p. 235) the latter terms where they would be most likely to be looked for, notifying, however, the origin and nature of the mistake. Here, however, we must reclaim them as really stems, and notice them accordingly.

With regard to their structure and arrangement, stems are *simple* (fig. 1, Plate III.), as those of the white lily among flowers, and the palms among trees; or *branched*, as in most trees and shrubs (fig. 3, Plate III.); they may be *hollow*, as in the grasses and *umbelliferæ*, but more generally they are *solid*. They may be herbaceous or woody, jointed or unjointed, procumbent or erect, and standard or twining and climbing.

The stems of most plants not only rise from the root, but from the ground. They bear branches, leaves, flowers, and fruit. Most of them are able to support their own weight,

Fig. 5.

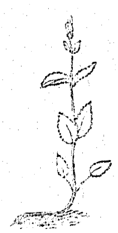


Fig. 6.

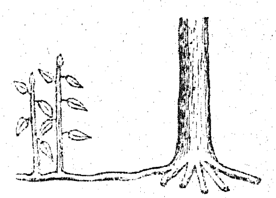
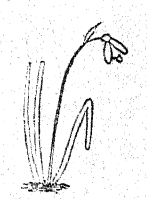


Fig. 7.



and are described as *ascending;* some make their way along the ground, and are called creepers; some seem to fall on the ground, and are designated *decumbent* or *procumbent* (fig. 5, Plate III.); others wish to rise, but cannot support themselves without the aid of their neighbours, round which they twine, as do the convolvulus and the hop. These invariably maintain their twining or climbing course to the right (fig. 3) or the left (fig. 4), towards or from the sun. Many plants have a stem which runs along the ground for a short way at first, and then rises, as the speedwells (fig. 5). These are said to be *decumbent at the base*. With one variety of the stem, the *prostrate*, we are familiar in the strawberry (fig. 4, Plate III.) It is called a *runner*. It is not a proper stem, for it gives off no branches nor leaves; and it is not a root, for it does not go down into the earth, and the roots are quite distinct. Another variety is the *sucker* (fig. 6). It is a new stem given off by the root at some distance, as in the poplar.

In many plants the stem is entirely wanting. In these the leaves, and the flowers also, spring from the ground directly, without stalks. What is commonly called the *stem* of a snow-drop is not *a botanical stem*, as it has no leaves on it, and no branches. It is called a *scape* (fig. 7). Such are, for instance, the so-called stems of some garlics, and most of those plants which have bulbous roots. A stem is *simple* if it gives off or divides into no branches, having only the pedicels or flower-stalks and the leaves attached to it; if, on the contrary, it divides more or less frequently, it is said to be *compound*. When this division takes place regularly in successive pairs (fig. 2, Plate III.) it is said to be *dichotomous*.

The following varieties are illustrated in Plate III.:—Figs. 6 and 7, Scandent Stems; fig. 8, Voluble; fig. 9, Articulated; fig. 10, Winged with thorns; fig. 11, Phyllodium (petiole developed in a leaf-like manner); fig. 12, Leafless, Succulent, or Deformed; fig. 13, Petiolate (opposite).

In the lowest kinds of vegetation the nourishing fluids are absorbed from the ground by *cells*, which form *pith* and structures like it, while in the higher orders, the *tubes* or *vessels* can actually be seen. In herbaceous plants the cellular tissue is interspersed with fibres, as any one may see on

breaking a stem of grass, or the blade of a cabbage. These fibres, when examined with the microscope, are seen to be distinctly tubular. This may be illustrated by the cross and horizontal sections of a stem (figs. 9, 10), in which these vessels may be seen. Between the green softness of herbs, and the woody texture of shrubs, there is an intermediate tribe, so far as mere structure is concerned. In these there is a hard woody shell on the outside, next a spongy part containing vesicular fibres, and lastly a large mass of pith in the centre, as in the common bramble. Pith is, at first, soft and green, altogether cellular and without vessels. It is doubtless of use in the growth of the young plant before the vessels have been properly formed, *i.e.* during its transition from being cellular to becoming vascular. All shrubs and trees possess pith, but in most of them it is exceedingly small at the very centre. In old stems it is frequently found quite dried and shrivelled up—a proof that it is no longer serving any useful purpose. The gradual compression and lessening of the pith by the growth of the surrounding wood is well seen in the bourtree or elder. Every country boy knows that its long straight shoots are very light, having a thin shell; and that three-fourths of their thickness consists of pith, while trunks of several years old have these proportions reversed, the wood being, perhaps, half an inch thick, while the pith is reduced to one-eighth.

In the lowest division of plants, the woody fibres are few and imperfect. They consist of the vessels through which the juices are drawn up from the root to the leaves and flowers, imbedded in a quantity of cellular tissue. The stalk of cabbage (*Brassica*) is an example. Cut it across when of full size, and the outside will be found to be woody, the centre soft and spongy; split it down and it will tear, showing numerous fibres, which are its vessels. That delicate substance called rice-paper is just the stem of a plant about an inch thick, in which the fibres are so few and far between that it looks like, though it is not, a mass of pith, for it has pith in its centre. It is cut spirally with some sharp instrument into layers, to form a thin plate, which is then unrolled, pressed flat, and cut into pieces of about a foot square. Those plants in which the fibres are numerous and tenacious are made useful in a different way. They are steeped in water until the soft cellular tissue between the fibres becomes soft. They are then beaten until it is removed, and only the fibres left. In this way, flax and hemp are made ready for the artisan, who *heckles* or cleans and combs the fibres, so as to be fit for the spinner.

Classes cannot be so absolutely marked off and distinguished one from another by any single characteristic, that the possession of that one alone shall unmistakably indicate its precise place in the system of nature—the subtlety of which eludes all merely verbal classification. Still, as holding generally true, we may say that as regards their structure plants are of two sorts, (1) cellular and (2) vascular, and that they are, according to the nature of their growth, divisible into these three classes, viz.:—

1. Plants are	1. Cellular,	1. *Thallogens* (leaf-like growers)	I. *Acotyledons.*
		2. *Acrogens* (top-growers),	
	2. Vascular,	1. *Endogens* (inside growers),	II. *Monocotyledons.*
		2. *Exogens* (outgrowers),	III. *Dicotyledons.*

Thallogens exhibit the greatest simplicity of structure. They assume various forms. Some spread out like a leaf—simple, lobed, or branched; others present a crest-like shape, and some—like the mushroom—have a stalk, cap, and gills. They have, however, no *axis* or stem distinct from a leaf, but the two are combined together, as it were, and perform the office alike of leaf and stem. They are without woody fibre, the entire plant being composed only of cellular tissue.

Acrogens grow by additions to their summit. In them the stem is really formed from the bases of the fronds or leaves, which carry up the growing point with them, growth after growth. The simplest form of an acrogenous stem is seen in mosses and ferns. In our country ferns do not show much sign in their stem of the results of acrogenous growth; but in countries where the temperature is high, tree-ferns present stems of over 60 feet in height, having at their summit a tuft of leaves.

In *endogens* the stem is made up partly of cellular tissue and partly of fibro-vascular tissue. The one forms the soft portion and the latter constitutes the hard parts—those which are tough and strong. In such a plant—*e.g.* the narcissus, the iris, or the lily of the valley—on making a transverse section, we see a mass of cellular tissue with fibro-vascular bundles scattered irregularly through it, covered externally by a rind or false bark, the cuticle of which is very thin. This is clearly exhibited in fig. 11. Fig. 12 shows a longitudinal section of a cylindrical stem. As the bundles of tissue successively develop, they are placed in the centre within those which were first formed. These therefore are pushed outward and pressed together, so that in all such plants the outside is the hardest and most compact and the interior soft—exactly the reverse of what occurs in the growth of exogens. The stems of endogenous plants, as a general rule, do not produce lateral, but only terminal buds, and they are therefore unbranched. Very often the centre of endogen stems is hollow. They have, in fact, no well-defined pith, no cambium, no medullary rays or medullary sheath, and no true bark. The leaves of such plants are parallel in their venation, and the style in which they germinate is peculiar. The radicle is protruded from the embryo surrounded by a cellular sheath formed from the integument through which it forces its way. All the real corn-grain plants are endogenous. Of endogenous trees palms are the type. Many endogenous plants—besides the palms and the grain-grasses—are very lovely, and—like lilies and orchids—produce very beautiful flowers.

No buds appear on the sides of these trees. They are all collected into a common cone which springs from the very top of the tree. The banana (fig. 8) is an example of the

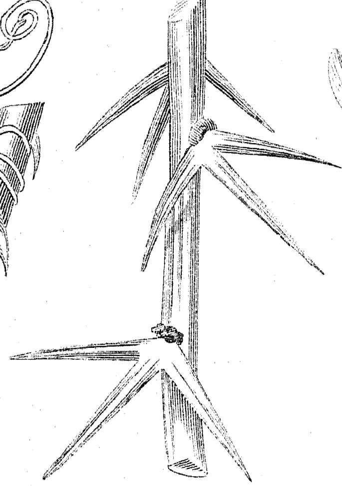
Fig. 8.

endogenous trees of tropical climates. It rises from 20 to 30 feet high, and is of nearly equal diameter throughout. A cluster of leaves is shown on the top. The lower one is hanging down, already withered. It will by and by drop off, as its predecessors have done, leaving their bases to form the outer covering of the new part of the stem. In the middle of the cluster is seen a *terminal bud.* It will be next developed, rise up, become a new cluster, and be similarly pushed away by its successor.

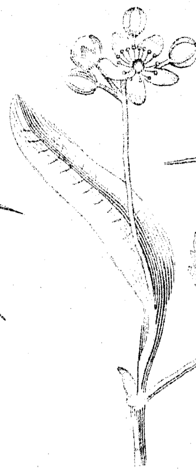
Plants of this description can never attain great thickness, but may arrive at great height. Certain species of the palm, with whose forms we are familiar in pictures of tropical and Eastern scenes, reach a height of 100 or even 200 feet, with a very moderate thickness at their bases.

It also results from the structure of endogens that the hard unyielding case which their external layers form, will

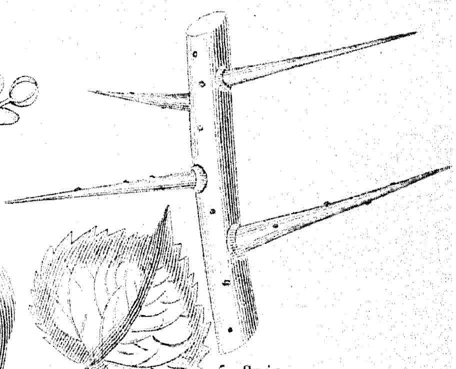
1. Tendrils. 2. Prickles (aculeate)



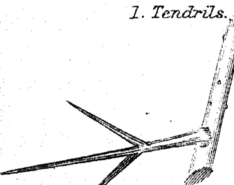
3. Pulvinus.



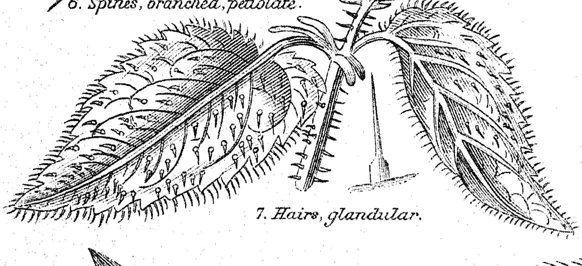
4. Bracts.



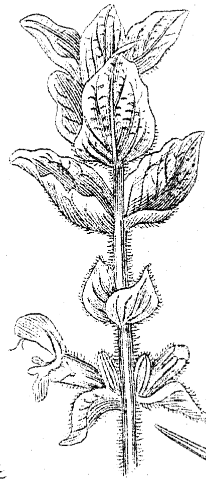
5. Spines.



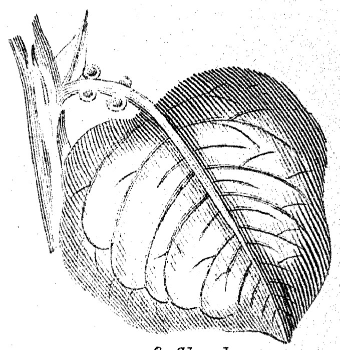
6. Spines, branched, petiolate.



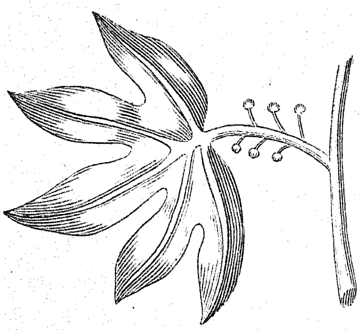
7. Hairs, glandular.



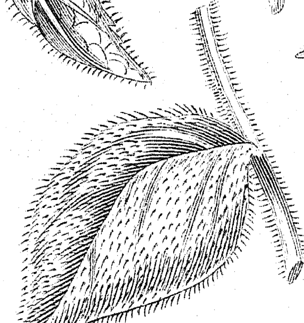
8. Verticillaster.



9. Glands.

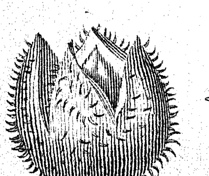


10. Glands, petiolate.

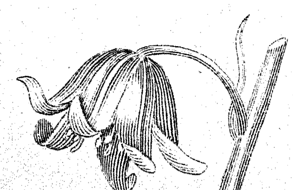


11. Hairs, simple, ciliated.

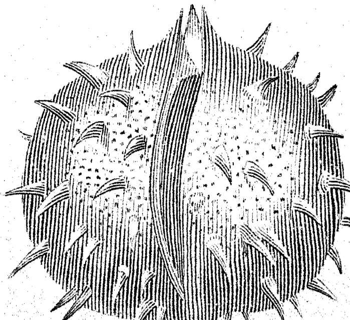
12. Inciso-dentatus.



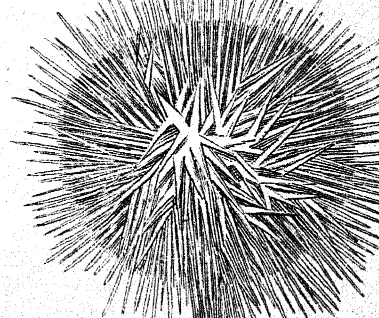
Septifrugal dehiscence. (fruit with hairs)



14. Bractlets.



15. Tricoccus. (fruit with prickles)



16. Echinatus. (fruit with spines)

become filled with the more recent growths, until the vascular tubes are so compressed that the juices can no longer flow through them, and the tree dies for want of nourishment. The age of these trees is consequently limited; two or three centuries is their utmost space, while exogenous trees have no such bounds set to their growth—the oak and the yew especially living for 600 or 700 years. Owing to the absence of those concentric rings which are seen when an exogenous tree is cut across, it is impossible to determine with accuracy the age of endogens; the only data we can guess from being the number of scars left on the outside after the annual decay of the top bunch of leaves.

Fig. 9.

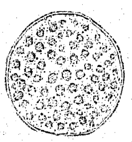
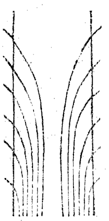
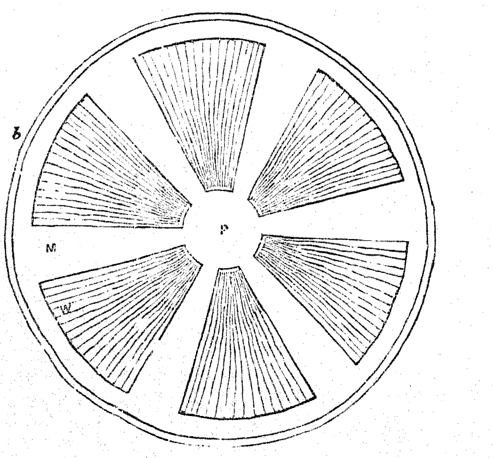


Fig. 10.



Exogens possess the most perfect and elaborate stems. All the active processes of plant-life are in them carried on in the outer layers of the wood. Zone after zone the new matter girdles the old with woody tissue. This enables us to understand how such plants can live and put forth new branches, though (as we often see in the trunks of old trees) the centre part is completely hollow and decayed. Fig. 11 is a plan of an exogenous stem cut across. It presents four distinct sets of parts—P, being the pith; *b*, the bark, in three layers, the inner being represented as continuous with the medullary

Fig. 11.



rays M; and W, the wood, consisting of woody fibre and vascular tissue intermingled.

The *pith* is a mass of cellular tissue, through which nourishment is sucked up, as through a sponge, before the vessels of the plant become formed, so as to carry on its normal circulation. It is found in all shoots or branches, and is in them of use; but in older branches, and in stems, its place is supplied by vessels formed to carry the juices up from the ground, and it very generally shrivels and shrinks away to nothing. In umbelliferous plants like the cow-parsnip the young shoots are filled with pith, while in the stems it has shrivelled up so as to leave them quite hollow.

The *bark* is the external covering of the stem, lying immediately over the wood, to which it forms a sort of sheath, and from which it is always distinctly separable. Its consists of three layers—*epiphlœum*, *mesophlœum*, and *endophlœum*.

The *epiphlœum*, outer or suberous layer of bark, consists of flat tabulated cells. In some instances it is very thin, and in others largely developed in a thick corky layer, which readily separates from the series below it, as in the cork.

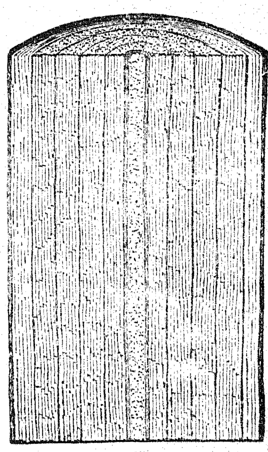
The *mesophlœum*, or middle layer, is generally developed to a less extent than the outer. It consists of cells differing in form from those of the epiphlœum, with thicker walls and intercellular spaces, as in the larch. The laticiferous vessels occur in this series. This layer is occasionally much developed.

The *endophlœum*, or *liber*, is the fibrous or vascular layer of the bark; it is the bast layer, so useful for textile purposes. During growth it separates into a kind of network, as in the lace bark and Cuba bast.

New bark is formed every year under the old, and therefore next the wood. As this new bark grows within that of the previous year, the latter, which is pushed outward, must more or less be extensible, according to the nature of the tree. There exists, however, a limit to the extensibility of old layers of bark; and when this is passed, the outer bark either splits into deep fissures, as in the oak, the elm, the cork, and most European trees, or it falls away in broad plates (as in the plane), or peels off in long thin ribbons, as in the birch.

A layer of bark, consisting both of cellular integument and woody fibre, is formed every year. It follows therefore that the age of a tree ought to be indicated by the number of such zones in the bark, just as it is indicated by the successive grains of the wood. But the arrangement of the zones is often disturbed, and the distinction between them becomes so imperfect that, even where the outermost coating is still entire, it is scarcely practicable to count them; and as soon as the outside begins to peel off, all certainty as to number of zones disappears. An evident proof that the bark grows from within is, that if a piece of iron be introduced just into the innermost bark or *liber* of a tree, in process of time it will be found protruded to the surface, and will at length fall away. A more obvious proof is, that a name cut in the bark of a tree by and by disappears; the letters get broader from the separating of their edges by the increased girth of the tree, their depth fills up by the new growth from within, and they finally fall off and disappear. That the nourishing juices rise through the woody vessels, and having been purified in the leaves, *descend* in the vessels of the inner bark, is proved by cutting a ring of the bark out, down to the wood, round part of a tree; the *upper* edge of the cut will be seen to grow, while the lower edge will remain stationary.

Fig. 12.



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The bark of numerous plants bears certain appendages to which the generic name of *trichome* has been given. These consist of cells arranged in column or in mass, and the most usual forms are shown in Plate IV., as follows:—Fig. 1, tendrils; 2, prickles, aculeate; 3, pulvinus (the cushion-like swelling occurring at the base of a leaf); 4, bracts; 5, spines; 6, spines, branched, petiolate; 7, hairs, glandular; 8, verticillaster (a false whorl formed in Labiates by the presence of short stalked or sessile cymes in the axil of opposite leaves); 9, glands (wart-like swellings formed on the surface of plants); 10, glands, petiolate; 11, hairs, simple, ciliated; 12, inciso-dentatus, having slashed toothings; 13, septifragal dehiscence (fruit with hairs); 14, bractlets (bracts of a second order, usually smaller and more changed than the true bract); 15, tricoccus, fruit consisting of three cocci, or elastically dehiscing shells with prickles (fruit with prickles); 16, echinatus, furnished with numerous rigid hairs or straight prickles (fruit with spines).

When stems are old, the bark generally bears but a small proportion to the thickness of the *wood;* yet, in some instances, its size is very remarkable. The bark of the cork tree is to be seen two inches in thickness, and the bark of an exotic fir has been brought to Europe not less than a foot thick.

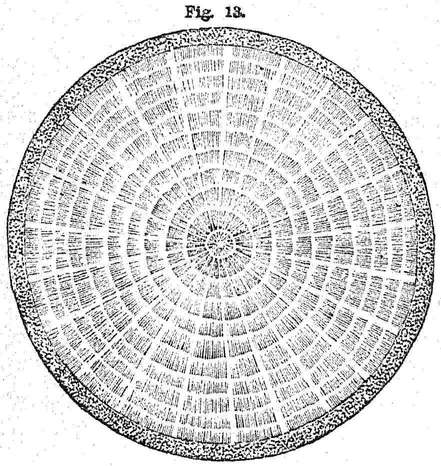
The *medullary rays* are the thin vertical plates seen connecting the pith with the bark. They are purely cellular, containing no vessels.

The *woody tissue* consists of fibres of vessels, occupying the space between the pith and the bark, divided into compact wedge-shaped vertical plates, whose edges rest on the pith

and the bark, and whose sides are in contact with the medullary rays.

In the shoot the cellular tissue of the pith and the bark are in contact; they are, in fact, but one substance, coated over by the epidermis. But the vascular system, with the woody fibres, as it forms, gradually interposes itself between them, till, after a few weeks, they are distinctly separated, and come, in aged trees, to be separated by a thickness of wood occupying several feet. In the twig of one year old (fig. 21, 1), the pith is seen surrounded by a layer of wood, by a layer of true bark, and by a layer of cuticle. The first layer of vascular tissue, formed between the pith or *medulla* and the bark, is the *medullary sheath* (figs. 12*m* and 21*m*). It remains next the pith ever afterwards, and the woody tissue forms on its outside. But while the first layer of vascular tissue is being deposited, it does not become interposed between the pith and the bark so as to separate them completely and form a perfect cylinder between them; it only displaces a quantity of the cellular tissue which joined them together, pushing it aside and compressing it into thin vertical plates (see fig. 13). As the vascular system increases, these plates increase outwardly, so that a horizontal communication between the centre and the circumference is still maintained. These medullary rays are called by cabinet-makers the *silver grain*. In a transverse section they are seen in fine lines radiating from the centre to the circumference (fig. 13): in

Fig. 13.



longitudinal section they produce that glancing satiny lustre which is more or less discoverable in all woods, and gives to some of them a character of remarkable beauty, as in mahogany and satin wood.

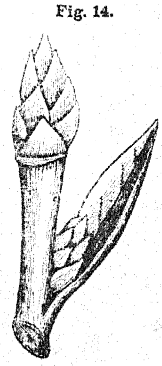
Wood in a few years acquires a colour different from what it possessed when first deposited. It becomes *duramen* or *heart-wood*. For instance, in the beech it becomes light brown; in the oak, deep brown; in Brazil-wood, green; and in ebony, black. It was originally colourless in all these, and owes its different tints to matter deposited gradually in all parts of the tissue, as may be easily proved by throwing a piece of heart-wood into nitric acid, when the colouring matter is discharged and the tissue recovers its original appearance. That part of the wood which, being last formed, is interposed between the bark and the heart-wood, is called the *alburnum*. Even of logwood, the alburnum is as white as fir. The heart-wood is much more durable than the alburnum, and is selected for any work that is wished to last well.

It is not easy, as we said, to guess the age of an endogenous plant, because it attains its greatest thickness rapidly, and afterwards only continues to grow in height—the new vessels, towards the centre of the stem, compressing those towards the outside. On the contrary, it is easy, theoretically, to determine the age of an exogenous growing tree, as the number of rings represent exactly the number of years it has been in existence. Except in the fir, however, and some other trees of very regular form, absolute accuracy is scarcely possible. In certain circumstances, probably of unequal exposure to the sun and weather, trees grow unequally, one side being much thicker from the centre than the opposite one. It is also much less easy to draw a correct conclusion from examining trees in warm climates than those in a temperate or frigid zone.

Buds are the means by which leaves, branches, and flowers are formed. They are a sort of germ, originating within the stem, from the surface of which they protrude ultimately and become developed. They usually consist of small *scales* or rudimentary leaves. These are closely wrapt around an axis, which is (1) either the termination of the stem and in a line with it, or (2) standing off at a certain angle. Within these scales there are other leaves, destined to be more highly developed than those which merely serve for the outer covering, and are either (1) to extend into branches, or (2) to expand into flowers. The protecting scales are frequently covered with down, which perhaps may aid in keeping out the cold; others are coated with gluten, an effectual protection against moisture, as in the horse-chestnut.

Buds may be either *terminal*, that is, at the end of the stem, or *lateral*, at its sides. Terminal buds are not general, for by them the growth of the stem or branch is put an end to — the bud breaking into a head of flowers. In most cases buds are formed where the leaves unite with the stem. They are generally situated immediately above the *axil* (armpit) of the leaf, that is, between the stem and the leafstalk, as is the case with the lower one in fig. 14. Buds may, however, under certain circumstances, be developed from any part of the stem. These are called irregular or adventitious buds, and are always found on the end of a medullary ray. By this means their connection with the central pith is maintained.

Fig. 14.



The *branches* or subdivisions of the stem are merely extensions of the trunk, for the support of the leaves and parts concerned in fructification. They present the same structure as the stem. In general, they come off

Fig. 15.

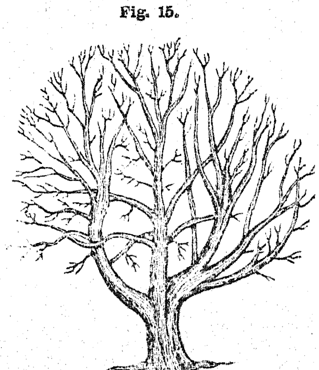
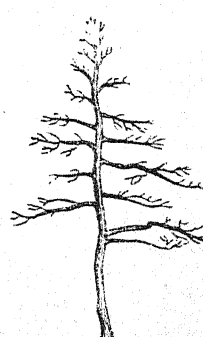


Fig. 16.



irregularly; but sometimes in two opposite ranks, and sometimes in four. In trees we observe four different ways in which they diverge from the stem. They may be (1) *patent* or *spreading* (fig. 15), as in by far the most of our trees; (2) *horizontal* or *divergent* (fig. 16), as in many of the pines; (3) *appressed* or inclined towards the stem, as in the Lombardy poplar (fig. 17); and (4) *pendulous* or *drooping*, as in the pendulous beech (fig. 18), or the weeping willow.

While yet very young, branches are denominated *shoots;* and when they arise from underground stems, and their leaves, instead of becoming developed, put on the form of scales, as in the common asparagus (fig. 19), the shoot is called a *turio*, *i.e.* sprout or tendril.

Branches are found on the stem of very many plants—especially of those which belong to the division of dicotyledons. But endogenous monocotyledonous plants do not generally put forth branches, and most monocotyledonous trees (as the palms) are without them. Branches have precisely the same organization as the stem, and may, in fact, be considered as

so many partial stems ingrafted on the main trunk. They originate from buds, and their arrangement round the stem depends upon the arrangement of the leaves, because the buds are placed in the *axils* between these and the stem. Branches are never, however, arranged so symmetrically as

Fig. 17.

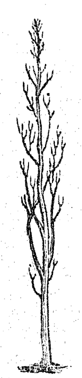


Fig. 18.

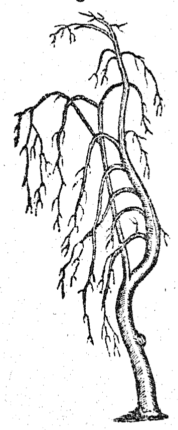


Fig. 19.

leaves, because a great many buds are never developed at all. The unfavourable circumstances under which many are placed, insufficiency of air, moisture, or light, cause especially those which originate on the lower parts of the stem to be either stunted or abortive.

When a bud has been formed, but has not grown into a branch, it still continues to live, and (carried out with the increasing bulk of the stem) awaits at the surface for a proper opportunity to *break* into a branch. This is the principle on which every gardener regulates the pruning of his trees. If a transverse section of a stem (fig. 20) be made where an undeveloped bud is seen to protrude, it will show the course the bud has followed as it passed from the centre outward, marked by a line or wake traversing the several layers. Hence, *branches* of the same age and size may be originated from *buds* which have been formed at very different periods of the tree's growth. The accompanying cut, fig. 21, shows a

Fig. 20.

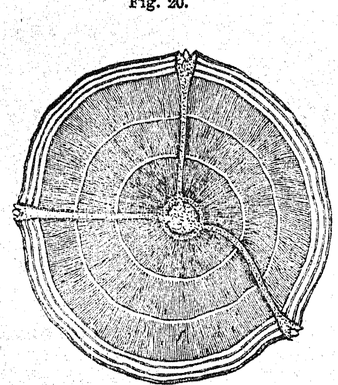
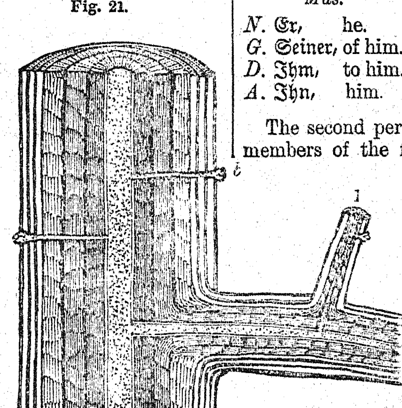


Fig. 21.



bud seated on a one-year-old branch (1); this branch is placed on another (2) which is two years old, and which originated from a bud the same age as *b*, which has not yet become developed.

THE GERMAN LANGUAGE.—CHAPTER VI.

PRONOUNS—SUBSTANTIVE AND ADJECTIVE: PERSONAL, POSSESSIVE, DEMONSTRATIVE, INTERROGATIVE, RELATIVE, INDEFINITE.

PRONOUNS are used instead of nouns to avoid repetition. They may be divided into (1) Substantive and (2) Adjective pronouns. The former are used entirely alone, like substantives, and do not always change their termination to indicate gender; the latter may be used joined to nouns like adjectives, and usually agree in gender with the noun they accompany or replace. (In fact when they are joined to nouns many grammarians consider them adjectives.) For simplicity we will treat them together.

Pronouns are divided into six classes, viz.—I. Personal, II. Possessive, III. Demonstrative, IV. Interrogative, V. Relative, VI. Indefinite pronouns.

The personal pronouns and the two interrogative and relative pronouns wer and was are invariably substantive; the possessive pronouns invariably adjective. All the others—demonstrative, interrogative, relative, and indefinite—are used both as substantive and adjective pronouns.

I. *Personal pronouns* point out (1) the person speaking, (2) the person spoken to, and (3) the person or thing spoken of, and therefore are called pronouns of the first, second, or third person. The German pronouns for these three persons are—for the first, ich, I; for the second, du, thou; for the third (mas.), er, he, (fem.) sie, she, (neut.) es, it; the plural, wir, we; ihr or Sie, you; sie, they. The declension of the personal pronouns is of ancient form. It cannot be subordinated to any general scheme, but is, on the contrary, quite peculiar. They are declined as follows:—

PERSONAL PRONOUNS.

FIRST PERSON.

Singular.		*Plural.*	
N. Ich,	I.	*N.* Wir,	we.
G. Meiner,	of me.	*G.* Unser,	of us.
D. Mir,	to me.	*D.* Uns,	to us.
A. Mich,	me.	*A.* Uns,	us.

SECOND PERSON.

Singular.		*Plural.*	
N. Du,	thou.	*N.* Ihr or Sie,	you.
G. Deiner,	of thee.	*G.* Euer or Ihrer,	of you.
D. Dir,	to thee.	*D.* Euch or Ihnen,	to you.
A. Dich,	thee.	*A.* Euch or Sie,	you.

THIRD PERSON.

	Singular.						*Plural.*	
	Mas.		*Fem.*		*Neut.*		*M. F. N.*	
N.	Er,	he.	Sie,	she.	Es,	it.	Sie,	they.
G.	Seiner,	of him.	Ihrer,	of her.	Seiner,	of it.	Ihrer,	of them.
D.	Ihm,	to him.	Ihr,	to her.	Ihm,	to it.	Ihnen,	to them.
A.	Ihn,	him.	Sie,	her.	Es,	it.	Sie,	them.

The second personal pronoun, du, is only used in regard to members of the family, relations, very intimate friends, and children, or towards inferiors in indication of contempt.

When Germans speak to strangers, to mere acquaintances, or to any person who deserves respect, they employ the plural of the third personal pronoun, and when the third personal pronoun is used in this way for the second it is always written with a capital letter; thus Sie means *you*, but sie means *they;* as Ich kenne Sie nicht, I do not know you; Ich will es Ihnen geben, I will give it you; Geben Sie mir meinen Hut, Give me my hat; Ich danke Ihnen, I thank you.

When two or more personal pronouns (in different cases) come together the *subject* is put first, the *direct object* next, and the *indirect object* last; as Geben Sie (subject) es (direct object) ihm (indirect object), Give (you) it to him.

The genitive case of the personal pronouns, in both numbers, is limited in its use. It occurs after certain verbs; as er lachet meiner, he laughs at me; ich schäme mich deiner, I am ashamed of thee. The plural genitive is put after numerals, and after viel and wenig; as unser zwölf, twelve of us; unser wenig, few of us.

Personal pronouns must agree in gender with the words for which they are used as substitutes; as Der Tag ist klar, aber

er ist nicht schön, The day is clear, but it (he) is not fine; Die Sonne scheint, aber sie ist nicht warm, The sun shines, but it (she) is not warm; Das Pferd ist groß, aber es ist nicht schön, The horse is large, but it is not handsome. Such pronouns, however, as refer to diminutives (which are almost always neuter in gender) generally agree with the natural sex of the being to which they refer; as Was macht ihr Söhnchen jetzt? Ist er wieder besser? How does your little boy now? Is he better again? Das kleine Mädchen weint weil sie ihre Mutter verloren hat, The little maiden weeps because she has lost her mother.

The neuter pronoun es serves to denote the action of impersonal verbs; as es regnet, it rains; es donnert, it thunders; but it is often also employed as an expletive, more to aid the sound than the sense of the sentence. In such a case it stands both before and after verbs, singular and plural, and corresponds to the English use of *it* or *there*, and like them serves to throw the nominative after the verb, which always agrees with the latter; as es sind Vögel, they are birds; es sind Hasen, they are hares; es sind Vögel da, there are birds there; es sind Hasen da, there are hares there. When, however, es is used with a personal pronoun the arrangement of the words is quite the reverse of the English. In the following expressions the difference between German and English is shown—

Ich bin es,	it is I.	Wir sind es,	it is we.
Du bist es,	it is thou.	Ihr seid es,	it is you.
Er (sie) ist es,	it is he, she.	Sie sind es,	it is they.

Es is often contracted to 's; as ich bin's, it is I.

The third personal pronoun, es, is rarely used after a preposition: in such a case da, there, is used instead of it, and da and the preposition form a compound word like the English therewith, thereto; *e.g.* Ich bin damit zufrieden, I am therewith contented, or contented with it. If the preposition ends with a vowel the letter r is placed after it; *e.g.* darin, therein.

In the first and second persons the accusative or dative of the personal pronouns are used as reflexive pronouns; as ich freue mich, I enjoy myself or rejoice; du freust dich, thou enjoyest thyself; wir freuen uns, we enjoy ourselves; ihr freut euch, ye enjoy yourselves. But for the dative and accusative of the third person (instead of ihm, ihn, ihr, sie, ihnen, and sie) sich is used for all genders; as er (or sie) freut sich, he (or she) enjoys himself (or herself); sie freuen sich, they enjoy themselves; er giebt sich (dat.) Mühe, he gives himself trouble; sie geben sich (dat.) Mühe, they give themselves trouble.

Almost all reflexive verbs require the accusative; only a few the dative.

The plural sich is also used in a reciprocal sense; as die Hunde beißen sich, the dogs bite each other. But as sich might signify themselves, the Germans also use the word einander, one another; as sie lieben einander, they love one another.

Sometimes, for emphasis' sake, the word selbst, self, is joined to the personal pronouns; as ich selbst, myself; du selbst, thyself; er selbst, himself; sich selbst, one's self; wir selbst, ourselves, &c.

Selbst (or selber) either follows a noun or pronoun, or is placed at the end of the clause; as Ihr Sohn selbst sagte es mir, or Ihr Sohn sagte es mir selbst, Your son himself told me it.

II. *Possessive pronouns* imply that the object to which they are joined, or which they represent, is in the possession of some special one of three persons—the person or persons (1) speaking, (2) spoken to, or (3) spoken of. They are formed from the genitive of their respective personal pronouns, the latter assuming the form of adjectives, and are therefore rightly denominated possessive adjective pronouns. They always, except in poetry, precede and qualify nouns.

POSSESSIVE PRONOUNS.

SINGULAR.

Per.	*Mas.*	*Fem.*	*Neut.*	
1.	mein,	meine,	mein,	my.
2.	dein,	deine,	dein,	thy.
3.	sein,	seine,	sein,	his, its.
	ihr,	ihre,	ihr,	her, its.

PLURAL.

Per.	*Mas.*	*Fem.*	*Neut.*	
1.	unser,	unsere,	unser,	our.
2.	euer,	eure,	euer,	your.
	Ihr,*	Ihre,	Ihr,	your.
3.	ihr,	ihre,	ihr,	their.

* When used to address one or more persons.

The possessive adjective pronouns agree in number, gender, and case with the substantives which they qualify. They are declined after the strong declension of adjectives, but have, like the indefinite article, no inflexional termination in the nominative singular masculine, or in the nominative or accusative singular neuter.

	SINGULAR. *Mas.*	*Fem.*	*Neut.*		PLURAL. *M. F. N.*	
N.	mein,	mein=e,	mein,	my.	mein=e,	my.
G.	mein=es,	mein=er,	mein=es,	of my.	mein=er,	of my.
D.	mein=em,	mein=er,	mein=em,	to my.	mein=en,	to my.
A.	mein=en,	mein=e,	mein,	my.	mein=e,	my.

	SINGULAR. *Mas.*	*Fem.*	*Neut.*		PLURAL. *M. F. N.*	
N.	unser,	unser=e,	unser,	our.	unser=e,	our.
G.	unser=es,	unser=er,	unser=es,	of our.	unser=er,	of our.
D.	unser=em,	unser=er,	unser=em,	to our.	unser=en,	to our.
A.	unser=en,	unser=e,	unser,	our.	unser=e,	our.

The following phrases will show the way in which the possessive (adjective) pronouns are declined with nouns:—

	SINGULAR.	PLURAL.
	my dear father.	
N.	mein lieber Vater.	meine lieben Väter.
G.	meines lieben Vaters.	meiner lieben Väter.
D.	meinem lieben Vater.	meinen lieben Vätern.
A.	meinen lieben Vater.	meine lieben Väter.
	thy good sister.	
N.	deine gute Schwester.	deine guten Schwestern.
G.	deiner guten Schwester.	deiner guten Schwestern.
D.	deiner guten Schwester.	deinen guten Schwestern.
A.	deine gute Schwester.	deine guten Schwestern.
	his blue dress.	
N.	sein blaues Kleid.	seine blauen Kleider.
G.	seines blauen Kleides.	seiner blauen Kleider.
D.	seinem blauen Kleide.	seinen blauen Kleidern.
A.	sein blaues Kleid.	seine blauen Kleider.

In sentences like the following:—"He is a friend of *mine*," "an acquaintance of *ours*," the possessive pronouns are not used in German. In such cases the personal pronouns are used; as er ist ein Freund von mir, he is a friend of *me;* ein Bekannter von uns, an acquaintance of *us*.

When possessive pronouns are not immediately joined to, but refer to and stand for, nouns already mentioned or understood, they may assume one or other of three different forms, viz.:—

1. In a declension like the definite article, *i.e.* one in which they add the strong inflexion in all the cases. It differs therefore from the adjective possessive in form only in the nominative of the masculine and neuter and the accusative neuter —the only cases in which that pronoun has not the strong terminations.

2. In a declension with the weak terminations and having the definite article prefixed.

3. In a declension similar to the second form, but having the syllable ig inserted before the weak termination.

	First Form.		*Second Form.*		*Third Form.*	
M.	meiner,	mine.	der meine,	mine.	der meinige,	mine.
F.	meine,		die meine,		die meinige,	
N.	meines,		das meine,		das meinige,	
M.	deiner,	thine.	der deine,	thine.	der deinige,	thine.
M.	seiner,	his, its.	der seine,	his, its.	der seinige,	his, its.
M.	ihrer,	hers.	der ihre,	hers.	der ihrige,	hers.
M.	unserer,	ours.	der unsere,	ours.	der unsrige,	ours

	First Form.		*Second Form.*		*Third Form.*	
M.	eurer,	yours.	der eure,	yours.	der eurige,	yours.
M.	Ihrer,	yours.	der Ihre,	yours.	der Ihrige,	yours.
M.	ihrer,	theirs.	der ihre,	theirs.	der ihrige,	theirs.

The following examples will show how they are declined throughout all their cases in these several forms:—

	SINGULAR.			PLURAL.
	Mas.	*Fem.*	*Neut.*	*M. F. N.*
1. *N.*	mein=er,	mein=e,	mein=es,	mein=e.
G.	mein=es,	mein=er,	mein=es,	mein=er.
D.	mein=em,	mein=er,	mein=em,	mein=en.
A.	mein=en,	mein=e,	mein=es,	mein=e.
2. *N.*	der mein=e,	die mein=e,	das mein=e,	die mein=en.
G.	des mein=en,	der mein=en,	des mein=en,	der mein=en.
D.	dem mein=en,	der mein=en,	dem mein=en,	den mein=en.
A.	den mein=en,	die mein=e,	das mein=e,	die mein=en.
3. *N.*	der mein=ige,	die mein=ige,	das mein=ige,	die mein=igen.
G.	des mein=igen,	der mein=igen,	des mein=igen,	der mein=igen.
D.	dem mein=igen,	der mein=igen,	dem mein=igen,	den mein=igen.
A.	den mein=igen,	die mein=ige,	das mein=ige,	die mein=igen.

Here also Ihrer, der Ihre, der Ihrige (with a capital I) is the usual way of expressing yours.

The first form, as at once the briefest and the least formal, is most usual in conversation; the others in literary composition.

The possessive pronoun must also always correspond with the personal pronoun which is used when speaking to a person; *e.g.* du corresponds with dein, ihr with euer, Sie with Ihr.

Die Meinigen, Deinigen, Ihrigen, &c., in the plural number signify those persons or things (*e.g.* family, property, &c.), belonging to me, thee, you, and are then written with a capital; as Er und die Seinigen befinden sich wohl, He and his family are well.

III. *Demonstrative pronouns* point out the objects to which they refer. They agree with them like adjectives. Among the most common are—

dieser,	diese,	dieses,	this (near at hand).
jener,	jene,	jenes,	that (remote).
der,	die,	das,	this, that (in either position).

Dieser and jener are both declined like the definite article. Dieses is often contracted into dies.

Der, when used *with* a noun, is the definite article, but when used *instead* of a noun it is a pronoun, and has some peculiar forms for the genitive and for the accusative plural; as

	SINGULAR.			PLURAL.
N.	der,	die,	das.	die.
G.	dessen,	deren,	dessen.	derer or deren.
D.	dem,	der,	dem.	denen.
A.	den,	die,	das.	die.

If *this* or *that* is separated from its subject by the verb *to be* it takes the neuter form of the singular without regard to the gender or number of the following noun; as dieses ist mein Knabe, this is my boy; but dieser Knabe ist mein, this boy is mine.

Dieser and jener are frequently employed to express contrast or comparison; jener then answers to the English the former, and dieser the latter; as Der ältere Bruder ist Arzt und der jüngere ist Kaufmann; jener hat eine zahlreiche Familie, dieser ist unverheirathet, The elder brother is a physician and the younger is a merchant; the former has a numerous family, the latter is unmarried.

The remaining demonstrative pronouns are—

derjenige,	diejenige,	dasjenige,	that, the one, &c.
derselbe,	dieselbe,	dasselbe,	the same.
der nämliche,	die nämliche,	das nämliche,	the same.

The student will at once observe that these are compound words; both parts are declined, and it is done in the way laid down for the definite article followed by an adjective; as

	SINGULAR.			PLURAL.	
	Masc.	*Fem.*	*Neut.*		
N.	derselbe,	dieselbe,	dasselbe,	dieselben,	the same.
G.	desselben,	derselben,	desselben,	derselben,	of the same.
D.	demselben,	derselben,	demselben,	denselben,	to the same.
A.	denselben,	dieselbe,	dasselbe,	dieselben,	the same.

These forms are not so independent as the three (dieser, jener, and der) above mentioned, for they do not usually stand alone, but should be followed by a possessive or relative clause; as

derjenige, welcher kommt,	he who comes.
diejenige, welche sprechen,	she who speaks.
dasjenige, welches ich meine,	that which I mean.
diejenigen, welche bereit sind,	those who are ready.

IV. *Interrogative pronouns* are used in asking questions. They may be either adjective or substantive. The former are also used as relative pronouns. Real interrogative pronouns are of the substantive kind, and are wer, who, for the masculine and feminine, and was, what, for the neuter; but the interrogative pronouns are usually given as wer, who; was, what; welcher, welche, welches, which, what.

DECLENSION.

	Mas. and Fem.		*Neut.*	
N.	wer,	who.	was,	what.
G.	wessen,	whose.	wessen,	of what.
D.	wem,	to whom.	was,	to what.
A.	wen,	whom.	was,	what.

Welcher is declined like the definite article, and is used before nouns, while wer is used alone or before verbs; as

Welcher Mann?	Which man?
Welches Haus?	What house?
Wer ist dieser Mann?	Who is this man?
Wer ist diese Frau?	Who is this woman?
Wessen Haus ist das?	Whose house is this?
Wem schreiben Sie?	To whom do you write?
Wen suchen Sie?	Whom do you look for?
Was sagen Sie?	What do you say?

The pronoun was, accompanied by the preposition für and the indefinite article ein, may be employed as an interrogative, and answers to the English "what kind-of a," but the noun is not necessarily put in the genitive case.

Was and für are invariable, but ein varies to agree with the gender, number, and case of the noun it refers to; as Was für ein Soldat ist jener? What sort of a soldier is that one? In was für einem Haus wohnt er? In what sort of a house does he live?

In the plural the indefinite article disappears; as Was für Männer? What kind of men? Was für Pferde? What kind of horses?

When used without a noun the nominative shows the gender; as Was für einer? Was für eine? Was für eines?

Was followed by auch in the same sentence signifies the English whatever; as was Sie auch sagen mögen, whatever you may say.

V. *Relative pronouns* refer to some person or thing previously spoken of; they are welcher, welche, welches, and der, die, das. They are declined as follows:—

	SINGULAR.			PLURAL.	
	Mas.	*Fem.*	*Neut.*	*M. F. N.*	
N.	welcher,	welche,	welches,	welche,	who, which, that.
G.	dessen,	deren,	dessen,	deren,	whose, of which.
D.	welchem,	welcher,	welchem,	welchen,	to whom, to which.
A.	welchen,	welche,	welches,	welche,	whom, which, that.
N.	der,	die,	das,	die,	who, which, that.
G.	dessen,	deren,	dessen,	deren,	whose, of which.
D.	dem,	der,	dem,	denen,	to whom, to which.
A.	den,	die,	das,	die,	whom, which.

These pronouns agree in gender and number (but not in case) with the nouns they refer to; as der Mann dessen Kind ist hier, the man whose child is here; die Frau welche (or die)

ich sah, the woman (whom) I saw; die Leute deren Häuser sind verbrannt, the people whose houses are burnt.

Welche in the plural is familiarly employed for some or any; as Haben Sie welche? Have you some?

If a sentence begins with a relative pronoun the verb is in simple tenses placed at the end; as das Buch welches Sie lesen, the book you read; but in compound tenses the auxiliary verb closes the sentence: der König, welchen ich gesehen habe, the king, whom I have seen.

Relative pronouns must always be expressed in German and never understood. Relative pronouns often combine with prepositions which precede them, so as to form single words; *e.g.* womit (mit welchem), with which, or wherewith; wofür, wherefore, or for which. These contractions are also used interrogatively—wofür? why?

The relative pronoun in the genitive case must always precede the noun which governs it, just as the English word *whose* does.

The interrogative wer is often used instead of derjenige welcher, he who, and was instead of dasjenige welches, that which; as Wer zufrieden ist ist glücklich, He who is contented is happy; Was schön ist ist nicht immer nützlich, That which is beautiful is not always useful.

VI. *Indefinite pronouns* are used to express the vague and undefined ideas which we sometimes have concerning things.

The following do not change to indicate gender, and are used substantively, *i.e.* they are not joined to a noun:—

man,	one, they, people.
jedermann,	everyone, everybody.
jemand,	some one, somebody.
niemand,	no one, nobody.
etwas,	anything, something.
nichts,	nothing, not anything.
selbst (or selber),	self.
einander,	each other, one another.
einige,	some.
beide,	both.
mehrere,	several.

Jemand and niemand are sometimes declined thus:—

N.	jemand,	somebody.	*D.*	jemandem,	to somebody.
G.	jemandes,	somebody's.	*A.*	jemanden,	somebody.

But usually they are treated like jedermann, which generally takes s in the genitive, and does not change in any of the other cases; as es ist jemands Kind, it is somebody's child; es gehört niemand, it belongs to nobody.

When the termination es is used in the genitive it is in order to avoid an abrupt sound; as es ist das Kind jemandes, it is somebody's child.

The other pronouns given above are indeclinable, but the oblique cases of man are supplied from the indefinite article: nom. man, or einer, one; gen. eines, of one; dat. einem, to one; acc. einen, one; as Sagt man so? Do they (or people) say so? Es thut einem leid, It makes one sorry.

The following can be used substantively or adjectively:—

einer,	eine,	eines,	one, some one.
keiner,	keine,	keines,	none.
jeder,	jede,	jedes,	every, each, any, every one.
aller,	alle,	alles,	all, everything.
solcher,	solche,	solches,	such, such a one.
mancher,	manche,	manches,	many a, many a one.
irgend einer,	irgend eine,	irgend eines,	any, anyone.
wenig,	wenige,	wenig,	little; wenige, few.
viel,	viele,	viel,	much; viele, many.
der andere,	die andere,	das andere,	the other.
der namliche,	die namliche,	das namliche,	the same.

The two latter are declined like an adjective preceded by the definite article (gen. des anderen; dat. dem anderen, &c.) The others are declined like the definite article (gen. jedes, jeder, jedes; dat. jedem, jeder, jedem, &c.)

One's before a noun is expressed by sein; as Man liebt sein Hund. One likes one's dog.

The English pronoun *one* is omitted in German after an adjective; as Ich habe einen schwarzen Rock und einen braunen, I have a black coat and a brown one.

In the same way the word *some* is often omitted; as Haben Sie Tabak? Have you *some* tobacco?

EXERCISE.

Commit to memory the following parts of the verbs sein, *to be*, and geben, *to give*. Then carefully translate into German the following sentences and write them out, using meanwhile English letters, *e.g.*, *sie ist deine Schwester.*

After this is done compare the exercise with the German translation given below, and underline and correct all mistakes.

Lastly, read each German sentence over repeatedly (aloud) till each has become so familiar that on looking at the English sentences the German translation can at once be given.

ich bin,	I am.	wir sind,	we are.
du bist,	thou art.	Sie sind,	you are.
er ist,	he is.	sie sind,	they are.
ich gebe,	I give.	wir geben,	we give.
du giebst,	thou givest.	Sie geben,	you give.
er giebt,	he gives.	sie geben,	they give.

1. She is thy dear sister.
2. He is my dear brother.
3. There is a dog in the yard.
4. They give themselves much trouble for (für) it.
5. He himself gives it to you.
6. Our children are all there.
7. His blue coat is in your (*dat.*) room.
8. Her girl is not so strong as (als) yours.
9. This stick is mine and that is yours.
10. Who is the man who gives you such presents?
11. It is I who give it to him.
12. Which child is ill? This one.
13. The man to whom you gave (gaben) it is dead.
14. Give (you) it to those who are ill.
15. One can not be everyone's friend.

TRANSLATION.

1. Sie ist deine liebe Schwester.
2. Er ist mein lieber Bruder.
3. Es ist ein Hund in dem Hof.
4. Sie geben sich viel Mühe dafür.
5. Er selbst giebt es Ihnen.
6. Unsere Kinder sind alle da.
7. Sein blauer Rock ist in Ihrem Zimmer.
8. Sein Mädchen ist nicht so stark als die Ihrige.
9. Dieser Stock ist meiner und jener ist Ihrer.
10. Wer ist der mann der Ihnen solche Geschenke giebt?
11. Ich bin es der es ihm gebe.
12. Welches Kind ist krank? Dieses.
13. Der Mann wem Sie es gaben ist todt.
14. Geben Sie es denen welche krank sind.
15. Man kann nicht jedermanns Freund sein.

ENGLISH GRAMMAR AND COMPOSITION.

CHAPTER IV.

PRONOUNS DEFINED, CLASSIFIED, EXPLAINED, AND EXEMPLIFIED.

Language, as we have it, is a growth. The convenience and inclination of the majority regulate its formation and govern its usages. The signs of thoughts are words; but our thoughts are mainly of persons and things, and hence we tend to use our words as if they denoted rather than symbolized the persons or things which occupy our thoughts. Symbols are marks with understood meanings. In the progress of experience these signs become so habitually employed that in the course of time we can symbolize these symbols—as shorthand is the abbreviated representation of the written signs of speech. Habit and use make the employment of such simple contrivances easy, and the advantage derived from their adoption inclines and enables the mind to make further progress in the same lines of invention. It has been so in

many of the exercises of the mind, and notably so in grammar. A single adverb symbolizes a lengthy phrase, and a conjunction saves the repetition of many words. The pronoun is, perhaps, the most signal triumph of this intellectual ingenuity.

Pronouns are usually and rightly defined as words used instead of nouns. In this way they enable us to avoid the repetition of the nouns for which they stand, and they might therefore, with some measure of appropriateness, be called nouns of the second order, or secondary representatives of persons and things. As nouns mark off and stand to the mind instead of things existing (or conceived to exist) in nature, so pronouns are the representatives of nouns or names, not the direct signs of things. Each noun has its own defined and distinctive representative power stored up in the memory as applicable to experiences, but the pronoun may be used as the representative of an unlimited variety of nouns, and have not a distinct and unvarying, but only an accidental and conventional, representative character. The mind recognizes this as the function of the pronoun, by the necessity it continually feels itself under of referring from the pronoun to the noun, in order that it may know who or what is intended to be denoted by it. If the pronoun is so placed or used that this reference cannot be made with readiness and certainty, hesitancy is felt in accepting a statement, and obscurity is complained of when we are thus in a difficulty to understand decisively to whom or to what a pronoun refers. In addition to this special distinction between nouns and pronouns there is yet another and a most important one. Nouns do not, in themselves, connote their respective relation one to another, or indicate their presence or absence (really or ideally) as regards one or another of the persons or things they denote, but pronouns do. By pronouns also we can speak to or of persons or things whose names we do not know, or who—even if we did know them—are too numerous to be mentioned. A majority of the House of Commons can thus briefly designate themselves as "we." Meeting an unknown person on the road, to whom I also am a stranger, I can say, "Would *you* be so good as tell *me* the way to"—any place I might be anxious to reach. As a member of a public meeting one might require to use the terms, "Let *us* so unanimously declare *our* resolution, and in such terms that *they* cannot misunderstand *us*—that is, *my* friends, the proposal *I* make to *you*." It would be very difficult now to translate these phrases into equivalent ones, in which nouns alone were employed where the italicized pronouns are used. Pronouns therefore not only represent nouns concisely and precisely, but, as their representatives, do a great deal more for them than they can do for themselves.

Every pronoun must be used as the representative of, or the substitute for, (1) the name of some person or thing; (2) for some person or thing unnamed; or (3) for some pronoun previously used; and with that understood or indicated *name* it must agree in having or suggesting the same number, gender, and case. Any carefully observant mind will notice that there are really these three forms of substitutionary representation:—

(1) Substantive—without noun named, and instead of one; as, *I* am here; *we* have come; *thou* art the man; *ye* cannot enter.

(2) Adjectively—as including not only a reference to a noun, but some quality connected with it; *e.g.* Whose book is *this* [book]? It is *mine* [=my book]. The mistake is yours [=your mistake]. His [=some certain and previously-named man's] praise is in all the churches. Is the fault his or hers? [=the result of some particular man or some particular woman's conduct or action.]

(3) Relatively—referring to some noun expressed or understood, implicitly known or requiring to be known; *e.g.* Who said so? implying, Some one said so; I require to know who? He *that* hath knowledge spareth his words= He spareth his words *that* hath knowledge, or A person sparing of his words hath knowledge. What hat have you got? implying, Of any special quantity of hats which particular one is it you have got?

Pronouns may be regarded as constituting three primary classes:—(1) Personal or Substantive; (2) Adjective; and (3) Relative. To these, however, for the sake of completeness, we may add the following three subordinate classes:—(4) Demonstrative; (5) Distributive; and (6) Indefinite; and several peculiarities in the use of special pronouns requiring notice are considered by grammarians as a justification for recognizing three other subclasses—(7) Interrogative; (8) Reflective; and (9) Reciprocal.

The idea of personation is taken from the Greek stage, where the dramatic characters wore masks while representing the persons in the play. The dialogue of the early stage plays was arranged so that the least possible number of speaking characters were employed. Two was the fewest, and these were respectively the first and second persons, while all other persons or things spoken about—by an ambiguous and somewhat inconsistent extension of the usage of the word *persona* (a mask or character) to comprehend things, animate or inanimate, usually excluded from the class person—constituted what was called the third person. In discourse one with another, grammarians grouped mankind and the things surrounding and interesting them into three classes, who might be considered as performing distinct parts in the drama of life. These are, the *first* person—the person (really or imaginarily present) who *speaks* to another (or others); the *second* person—the person *spoken to;* and the third person—the person *spoken about*, comprehending for convenience' sake under this heading every kind of being that can become the object of thought, whether persons (properly so called) or other things to name which nouns are used, and the names of which pronouns may represent.

I. *Personal pronouns* represent the names of persons. Of these there are five:—*I*, *thou*, *he*, *she*, and *it*. *I* represents the first, *thou* the second, and *he*, *she*, and *it* the third person.

As the first and second persons are presumed to be in each other's presence, there is no need for any sign indicative of sex in these pronouns; but in the third person, as in the greater number of instances the persons or things meant may not be present, provision has been made for indicating sex. *He* represents masculine, *she* feminine, and *it* neuter nouns. These personal pronouns therefore (1) act as substitutes for nouns, (2) denote presence or absence, and while doing so (3) indicate *gender* and (4) distinguish *person*.

The personal pronouns are thus varied:—

	Singular.			Plural.		
	Nom.	*Poss.*	*Obj.*	*Nom.*	*Poss.*	*Obj.*
1st Person, Masc. or Fem.	I	Mine	Me	We	Ours	Us.
2nd " " "	Thou	Thine	Thee	Ye or You	Yours	You.
3rd " Masculine	He	His	Him	They	Theirs	Them.
3rd " Feminine	She	Hers	Her	They	Theirs	Them.
3rd " Neuter	It	Its	It	They	Theirs	Them.

Personal pronouns are often used substantively (*i.e.* as nouns), and do not represent any *special* or *particular* person or persons. The difference between these uses will be seen in the following examples, viz.—*Pronominally.* James cannot succeed, because *he* [James] is slothful. *Substantively. He* [the person] who is slothful cannot succeed. The pronoun, as representative of a noun, is subject to the same restrictions of number, meaning, &c., as the noun whose place it supplies; as, The reasonings of a logician ought to be accurate, for *they* are the results of the study of the laws of thought. *They*, in this case, represents the word *reasonings*, qualified by the consideration that they are those "of a logician."

They, besides being the plural of all three forms of the third personal pronoun, is employed in an indeterminate or general manner, in which usage it has no special reference to any particular person; as, *They* say the funds are falling. *They* (=people) who adopt such measures can scarcely be worthy of trust.

We, *you*, and *your* are sometimes also used in a similarly indefinite way; as, *We* all profess that *we* love virtue—meaning, Everybody professes that they love virtue. The Bass lies before *you* as *you* look outward on the sea—where *you* means any person. Oh *your* satirical versifier, how I dislike him!—where *your* has the indefinite sense of *any*.

The pronoun *it*, though generally included among the personal pronouns, is, strictly speaking, an *impersonal* one. Its use is very peculiar and difficult. Perhaps the following

remarks and examples may aid the student to employ it with accuracy:—

1. *It* is the representative of any inanimate existence, as—

> "The air . . .
> I know *it* has been trifling with the rose,
> And stooping to the violet."—*N. P. Willis.*

2. *It* is used as a vague embodiment of any circumstance or state; as, "Methinks *it* is good to be here." "Ill fared *it* then with Roderick Dhu." How goes *it* with you, friend? *It* rains, &c.

3. *It* is often employed to form an easy and agreeable commencement of a sentence, either as (1) the introducing nominative to a clause or phrase, or (2) as the substitute of one; as, *It* was vain *to contend against such a host of difficulties. It* was the *heretics* who first began to rail.

There is used in the same way and for the same purpose as *it;* as, *There* came a man to our house representing himself as your friend.

4. *It* is sometimes enclitical after intransitive verbs; as, I walked *it* all the way. He tries to lord *it* too much.

> "Whether the charmer sinner *it* or saint *it*,
> If folly grows romantic, I must paint it."

5. *It* is frequently, though in an inelegant and pleonastic manner, employed as a nominative to the verb *to be*, followed by another nominative and a relative; as, *It was* Ben Jonson *who* wrote "Every Man in his Humour." *It is* in Britain alone *that* we find liberty without license. The italicized words are quite unnecessary to express the sense.

6. *It* may even represent a masculine or a feminine noun; as, *It* is the great philosopher himself. *It* is the queen who gives the law.

7. *It* may represent a noun in the first or second person; as, *It* is I. Is *it* you?

8. *It* may represent a phrase; as, *It* has been repeatedly said, "Worth is wealth."

II. *Adjective pronouns* are pronominal words employed as adjectives, or with an adjectival meaning. They indicate, at the same time, both person and quality, as Own, &c.

Possessive adjective pronouns denote person and ownership; as His, mine, &c.

The possessive cases of the personal pronouns, as given on page 339, are frequently set forth in grammars as possessive adjective pronouns. They may stand alone, for they are used in place of a noun, whereas the adjective pronouns derived from and corresponding to them must be followed by the noun of which they indicate the possession. This will be seen on comparing the undergiven lines:—

Personal Pronouns Possessive.

Mine, thine, his, hers, its, ours, yours, theirs.

Possessive Adjective Pronouns.

My, thy, his, her, its, our, your, their, own.

By trying to form sentences with them this distinction will readily appear:—This book is [my book] mine. These flowers are [your flowers] yours.

Mine and *thine*—euphonic forms of *my* and *thy*—are sometimes used before words beginning with vowels; as, Mine eyes are weary, thine are wet.

Own is sometimes, though seldom, used singly, *i.e.* I am *own* sister to her; it is usually added to other pronouns to express possession more emphatically; as, It is all my *own.*

III. *Relative pronouns*—who, which, that, and what—are such as carry back the thoughts of the mind to an antecedent noun, or part of a sentence used as a noun; *e.g.* He wins *who* works. Industry is that *which* makes men thrive. He is a man *that* has been named before. I do not know *what* you want.

Who is applied to persons and things when personified; *which* to the lower animals, and objects named by neuter nouns; *that* is used to prevent the too frequent use of who or which, and after the words *same* and *all; what* is a compound relative including the sense of both *that* and *which* or *who.* It takes no antecedent, but embodies one; as, It desires *what* [=that which] it has not, the beautiful. They are declined alike in both numbers, thus—

Nominative—	Who, which, that.
Possessive—	Whose.
Objective—	Whom, which, that.

What, who, and *which,* when compounded with *ever* or *soever*, are called compound relatives.

Relative pronouns, with the clauses in which they occur, are equivalent to adjectives, and are consequently either (1) restrictive, or (2) explanatory; as—(1) I shall win a name *that* beauty will not blush to hear; not any name, but such an one as shall not bring the blush to beauty's cheek. (2) *He* must be a bad writer, or at least a very indifferent one, *in whom there are no inequalities.*

As the chief use of the relative pronoun is to enable us to express those compound attributes for which we have no appropriate adjectives in our language, they ought not to be used unless when this is the case.

That is most used restrictively, and *who* and *which* explanatorily; *e.g.* Where is the man *that* you spoke to me about? Where is the man *who* was promised this coat?

Very commonly the relatives *whom* and *which* are omitted both in speech and writing. Though it is often difficult to use these words euphoniously and consistently, the omission of them is not to be commended. Though Shelley says, "Men must reap the things [which] they sow;" Shakspeare, "There is a willow [which] grows ascaunt the brook"—omitting in these sentences the relative shown in brackets—yet such phrases as, *The man I speak of, The place I write from, The person I gave the letter to,* are not justified by such examples.

The relative *that* is never governed by a preposition. In "On *that* day," *that* is demonstrative; in "On the day *that,*" it is relative.

IV. *Demonstrative pronouns* point out the particular persons or things to which we refer. They are—*This, that,* with their plurals *these, those,* and *yon, yonder;* as, *This* man, *that* day, *yon* mountain, &c.

This and *yon* refer to the nearer or latter mentioned; *that* and *yonder* to the more distant or prior mentioned.

The *to* in the words to-day, to-night, to-morrow, &c., is really a remnant of the demonstrative *this.*

V. *Distributive pronouns* are employed when we wish to make assertions regarding the individuals of a class separately and severally. They are—*Each, every, either, neither.*

Each signifies two taken individually; *every*, many singly; *either*, one of two; *neither*, none of two. They are therefore singular.

VI. *Indefinite pronouns* are employed when we do not choose to limit our assertions to specific numbers, or are unable to do so. They are—*All, another, any, aught, both, certain, divers, few, much, many, none, naught, one, other, several, some, such, sundry, whit, whole.* For example, *any* means *one* of a number, but does not indicate *which* one; *some* signifies any number more than two and less than all, but does not indicate precisely which particular ones.

Who, in addition to its uses as a relative and an interrogative, may sometimes also be an indefinite pronoun; as—

> "The cloudy messenger turns me his back,
> And hums, as *who* should say, 'You'll rue the time
> That clogs me with this *answer.*'"—"*Macbeth,*" iv. 6.

VII. When information is either really or apparently sought the sentence seeking it is called an interrogative one, and takes a note of interrogation (?) after it, *e.g.* Who told you that? What were you told? Such sentences are mostly abbreviations of sentences, which, if written in full, would run somewhat thus:—I ask you to inform me who told you. I request you to state what you were told. On this ground an interrogative pronoun has been humorously, yet aptly, defined as "a relative in search of an antecedent."

Who, which, and *what,* when thus employed in asking questions, are called *Interrogative Pronouns.* As a relative pronoun *what* is always neuter; as an interrogative it is applicable to all genders.

We had formerly, and occasionally we yet use, an interrogative of a dual character, which asks us to determine our choice, as if it alternated between two things only—*whether; e.g.* Whether of the twain will ye that I release unto you? Whether do you go or stay? Whether is greater the gift or the altar?

VIII. *Reflective pronouns* are such as are used when an action reverts on the agent, that is, is reflected or bent back, as it were, so as to take effect on the doer of it. We have occasion to use such words, as in Byron's line—

"He sat him down at a pillar's base,"

but we have no class of words which has been set apart for the fulfilment of this office. The place of such pronouns is supplied, when the necessity is special, by the use of the nominative and objective cases of the noun *self, selves*, and for the possessive cases we use *own* in combination with some pronominal word. They are—*Myself, ourselves; thyself, yourselves; himself, herself, itself, themselves;* and sometimes also *ourself* and *yourself; e.g.* I myself also am a man; thou thyself art a guide; you yourself are much condemned; we will keep ourselves till supper time alone.

The use of *own* is shown in the sentences—Virtue is its own reward. I am guardian of mine own honour. To thine ownself be true.

IX. *Reciprocal pronouns* are those which are employed when mutual interchange of office or of action is employed or expressed, *e.g.* Love one another; help each other.

Each other refers to two; *one another*, to any number above two. Sometimes in the objective the preposition is inserted between the pronouns, Be kindly affectioned one to another; "Sighs . . . out of his breast each after other went."

One of the greatest philologers of modern times, Philip Karl Buttman, has said with great truth, "Pronouns cannot be so precisely defined as not to admit many words which may also be considered as adjectives." We would scarcely dispute regarding a matter so trifling as that of classification. If a word is used with adjectival force we would call it an adjective; if with pronominal force, a pronoun. What a word *does*, and not what it *is*, determines its proper grammatical designation as a part of speech.

EXERCISE.

Take two or three pages of any book and (1) mark by underlining in the text the several pronouns, as they occur; (2) go over the several marked pronouns and indicate, by placing the figures denoting the several kinds of pronouns in the preceding chapter, the class of pronouns to which each belongs; (3) construct a series of sentences in which the different pronouns, as given above, are introduced, with their proper signification.

GEOLOGY.—CHAPTER IV.

EARTHQUAKES: THEIR PHENOMENA—INCIDENTS AND EFFECTS OF EARTHQUAKES—GEOLOGICAL INTEREST OF EARTHQUAKES AND VOLCANOES—THE FORCES OF NATURE.

NOTHING, perhaps, produces a greater sensation on the mind of man than an earthquake. The convulsive heavings of the earth, the tottering of towers and other buildings, the crashing of timber, and the falling of tiles and houses, amidst the ghastly looks of terrified multitudes clinging to posts, or laying themselves prostrate, or on their knees, and imploring the mercy of Heaven—is a scene which none but those who have witnessed can well conceive.

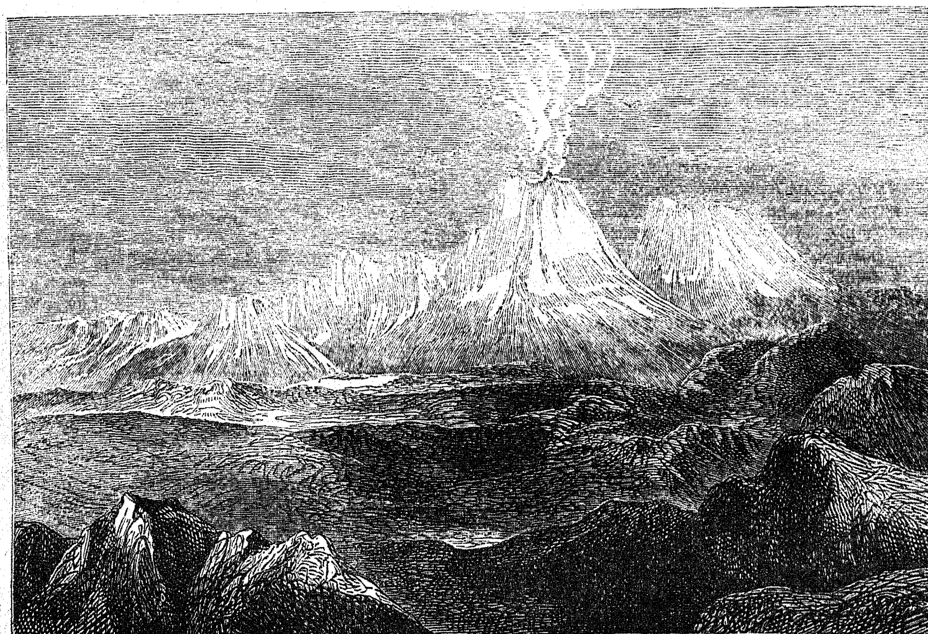
Earthquakes are more common in some countries than others. They have been recorded as occurring in sacred and classical lands from the dawn of authentic history. It would be almost impossible to refer to any portion of the globe, aqueous or solid, as certainly exempt from such evidences of instability. They occur in regions widely apart from each other, of wholly different climate, physiognomy, and geological constitution. Continental and insular tracts, rugged and level districts, dry and swampy plains, regions composed of primitive rocks, stratified masses, and alluvial deposits, have all alike been ravaged. These mighty internal agencies have made themselves felt on the high table-lands of the Andes, the low prairies of the Mississippi, the deep valleys of the Alps, the bleak steppes of Siberia, the hot sands of Syria, the moist flats of Holland, and the vine-clad hills of the Rhine. Irkutsk, with its vicinity, in Siberia, though more than a thousand miles from any part of the ocean, can hardly be called an exception, as it directly borders on the Great Lake Baikal, the "Holy Sea" of the Russians, whose mysterious movements, when not a breath of wind is astir to agitate the surface, are probably caused by some deep-seated subterranean commotion. It is, however, generally true, that shocks are more numerous and violent in maritime positions than in the far interior of continents. At nearly the antipodes of each other, the islands of Great Britain and New Zealand are included within the empire of the same conquering power. Happily the former have hitherto experienced either moderate indigenous shocks, or such as, being propagated from distant centres of convulsion, reach them with subdued or expiring energy. Earthquakes in the latter, though of frequent occurrence, and occasionally of alarming intensity, have not been very calamitous in modern times, nor do the traditions of the natives supply notices of their destructiveness. Yet their geology is exceedingly interesting and remarkable, for the evidence they yield of the existing action of subterranean heat—evidence derived not only from the pumice-peaks their hills display, and the volcanic activity of Tongariro, but from the forms their table-lands assume, the nature of some of their isolated peaks, and above all from the warm pools, the caldrons, and boiling lakes—like those of Rota Mahana—where grand and beautiful geysers throw up *jets d'eau* two degrees hotter than the boiling point, the waters of which are used not only for cooking purposes, but also as natural hot-baths.

The view of the matter now most generally taken by modern geologists is, that the elevations and depressions caused by earthquakes, the tilting up, the contortions and overlappings of strata, the crumpled-up appearances, and the actual breakages and dislocations of surfaces, are really caused by the contraction of the earth as it cools. The earth was undoubtedly much hotter long ago than it is now. During vast intervals the fierce heat with which it glowed has been gradually cooling and forming the outer crust. These exterior solidified portions are bad conductors of heat, and allow the interior heat to disperse itself with exceeding slowness. Still in the long lapse of ages, as the cooling process goes on, the inner hot matter must contract, and the external crust, under the enormous pressure of gravity, in seeking to adapt itself to the decreasing surface on which it rests, becomes squeezed, shrivelled, and broken. Through a network, as it were, of cracks in this upper crust—of which some parts are soft, yielding, and pliable to pressure, while others are rigid and inflexible (unless under exceptional exertions of power)—hot molten matter makes it way, steam and vapours seek outlet, and cause movements, tremors, convulsions, dislocations, contortions, and upheavals or depressions, in short, all the phenomena of earthquakes, and many of those displacements of strata which are so invaluable to the geologist in his endeavour to learn the story of the earth. Only thus is he—being unable to pierce through the stone-floor of the earth, and penetrate the rocks which lie lowest among the materials of the outer crust—put in possession of the opportunity of examining the rocks, of learning the order of their superposition, of gaining some clue to their history, and of gleaning some facts as to their relations in age and character. He is like a chronicler who, among the remnants of libraries and the debris of archives, finds from a volume here, an interpretative letter there, a mass of confused and old-fashioned literary matter elsewhere, and a row of soiled, dilapidated, and perhaps imperfect books in various languages and of different eras, the means, in some measure, of interpreting the past and writing its story so as to bring it into living relationship with the present time. The geologist is the historian and interpreter of the rock-written story of the earth and its changes.

Earthquakes furnish the most striking examples with which we are acquainted of the production of stupendous effects in very brief intervals. The most disastrous shocks are gener-

ally the shortest—in fact, over almost in an instant. In less than six seconds the thriving city of Concepcion was in ruins, with the earth opening and closing rapidly in all directions, and smothering clouds of dust rising from the prostrate buildings, which, when they cleared away, revealed the survivors of the calamity, pale and ghastly, as if the graves had given up their dead. By three shocks, all of which occurred in less than a minute, Caracas was levelled to the ground. The utmost duration popularly assigned to the earthquakes of Jamaica, 1692, and Calabria, 1783, amounted to three and two minutes. Yet the surface of a large extent of country was so completely altered that hardly a tract could be found retaining its former appearance. The effects of these mighty operations of nature comprise the permanent displacement of land, both by elevation and subsidence; the dislodgment of masses of rock; the opening of extensive fissures in the ground, both horizontally disposed and radiating from a centre, some of which close again, while others are stable; with the discharge of hot water, steam, mud, sand, flame, and columns of smoke from the surface. The immediate destruction of human life is of course the most fearful item. It is estimated that not less than 13,000,000 of the human race have perished in this way.

Earthquakes are not frequent in the insular kingdoms of Great Britain. Fortunately for its inhabitants a very small number of such alarming phenomena are recorded in their annals. The village of Comrie, in Perth, is the centre of more distinct disturbances of this sort than any other place in Britain, and the underground tremor felt there is often propagated over great areas. A rather notable earthquake signalized the annals of Aberdeen in August, 1816. Its wave was propagated throughout almost the whole of the north of Scotland. Dunkeld, in Perth, the Carse of Gowrie, Strathearn, Montrose, Inverness, Forres, and Dingwall all distinctly suffered from the vibrations and concussions which marked its course. The walls of houses were rent asunder, from the top to the bottom; many were permanently damaged otherwise, and the earth for some seconds was tossed like the sea. At Dornoch, where a mound crossed a narrow part of the firth, and had three arches formed in it to allow small vessels to pass through, the arches were thrown down, not by the fierceness of the sea, but the unsteadfast tossing of the land. Many were frightened, a few injured, but no evidence exists that any lives were lost. It is not often that such threatening earth-waves move the solid framework of



Pumice Hills, New Zealand.

our soil, though several instances are noted by our historians, and some have occupied the columns of newspapers, and for a brief period stirred the fears of men. There is no fixed season for the occurrence of earthquakes, but as they are always startling, and often destructive, the very name has become invested with terror.

The old chroniclers supply notices of earthquakes in England which, though of no scientific value, are occasionally piquant, and intimate the severity of these visitations. The Saxon Chronicle states, under the year 1089, there was "a mickle earth-stirring over all England," and the annalist records that the harvest was especially backward. In 1110, Florence of Worcester says, "there was a very great earthquake at Shrewsbury." The river Trent was dried up at Nottingham from morning to the third hour of the day, "so that men walked dryshod through its channel." Holinshed relates, that on the Monday in the week before Easter, in 1185, "there chanced a sore earthquake through all the parts of this land, such a one as the like had not been heard of in England since the beginning of the world, for stones that lay fast couched in the earth were removed out of their places, houses were overthrown, and the great church of Lincoln was rent from the top downwards." Matthew Paris mentions a shock on St. Valentine's Eve, in 1247, which was especially violent on the banks of the Thames, and did considerable damage in the metropolis. This was accompanied by an extraordinary calm along the coast, which continued for three months, as if the sea had ceased to ebb and flow, or at least the flow was not perceptible. Matthew of Westminster records a general earthquake on the 12th of September, 1275, "by the violence of which the church of St. Michael on the Hill, outside of Glastonbury, fell down levelled with the soil." Many other churches suffered in a less degree. The metrical annalist, John Harding, writes in his chronicle for 1382,

> "The earthquake was, that time I saw,
> That castles, walls, towers, and steeples fyll,
> Houses, and trees, and crags from the hill."

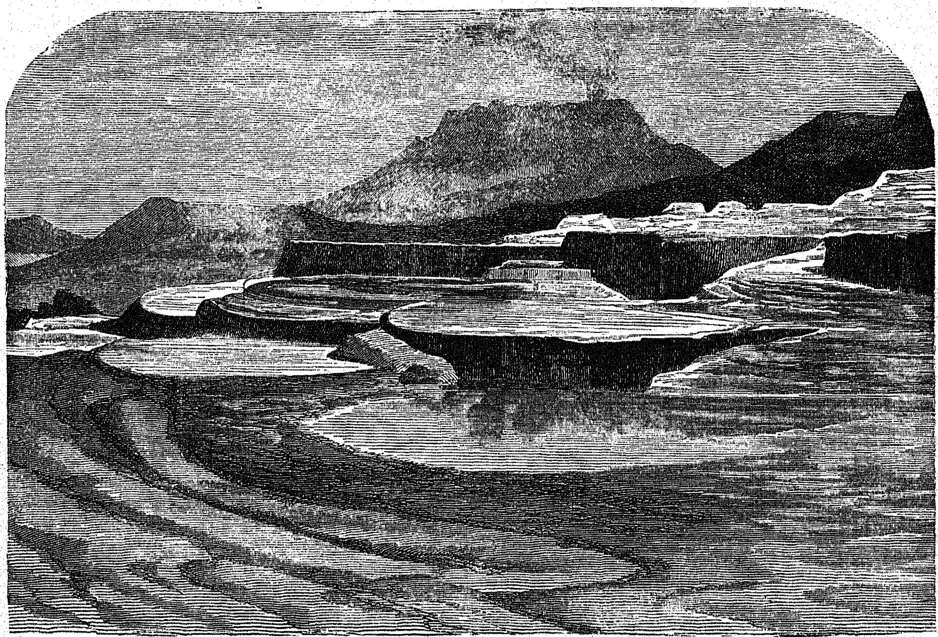
This was followed three days afterwards by what is styled a "watershake," when the ships in the harbours were driven against each other with great violence, and in some instances stranded.

A chronological account of shocks occurring in Great Britain has been carefully compiled by Mr. Milne. It includes those which have been mentioned with more or less clearness by respectable authorities, from the beginning of the seventeenth century to the autumn of the year 1839. The register commences with one felt generally in Scotland in 1608, which the

Aberdeen people interpreted as a rebuke for allowing salmon-fishing on Sundays in the river Dee. During the interval named, 116 shocks were experienced in England and Wales, and 139 in Scotland, making a total of 255. They may be arranged in two classes, general and local.

The *general* shocks, *i.e.* those experienced through a wide area of the kingdom, are of rare occurrence. They are mostly, if not exclusively, of foreign origin, and reach us as mere vibrations propagated mechanically along the earth's surface, from some focus of disturbance in a distant region. The *local* shocks, *i.e.* those which affect only small sections of the country, and are sometimes restricted to very limited areas of counties, comprehend the great majority of British earthquakes, and may be regarded as truly of home origin. Instead of being transmitted from foreign regions of disturbance, they appear to originate in, or emanate from, points immediately beneath the surface of our islands, at an unknown depth. This conclusion, besides being inferred from the scant limits of the areas affected, is sanctioned by the consideration, that in the districts disturbed there is usually some spot where the concussion is greater than anywhere else. Out of the 116 shocks recorded as having been observed in England, 31 were confined to the south coast, 14 to the borders of Yorkshire and Derbyshire, 5 or 6 to Cumberland, and 31 occurred in Wales. In Scotland, out of 139 shocks, 23 emanated from the Great Glen or its vicinity, and no less than 85 from Comrie or its neighbourhood. The remarkable number returned in connection with this Perthshire village is a very well attested fact. The Rev. Samuel Gilfillan, a shrewd observant minister, who resided there upwards of thirty years, was in the habit of noting in a private journal, not only the dates of any shocks which occurred, but also any striking effects or sounds which accompanied them. So well was this known that he acquired the popular title of "Secretary to the Earthquakes." Earthquake shocks have been still more frequent since the date of the register referred to. Some of these have been remarkable for their violence.

Earthquakes are frequently nothing more than a gentle tremor of the ground, scarcely obvious to the senses. Multitudes engaged in business or pleasure are unconscious of their occurence. No injury is done, and no superficial displacement is observed. The attentive alone perceive the vibration, which leaves as little trace of its activity as does a slight shiver experienced by the human frame. In some countries where feeble shocks are common, habit has so reconciled the inhabitants to them that they attract no more



Boiling Lake of Rota Mahana, New Zealand.

notice than a hailstorm with ourselves. But, twice or thrice in a century, the subterranean element acts in several of these regions with greater energy, alters the features of the landscape, changes the relative level of sea and shore, and prostrates the palaces of the high and the huts and hovels of the lowly. While destructive earthquakes are mercifully rare events, the phenomenon itself is of frequent, if not constant, occurrence, reckoning the slight with the severer expressions of it, in some part or other of the earth's surface. Thus, at Palermo, in Sicily, fifty-seven smart shocks were felt in the space of forty years; at Copaipo, in the north of Chili, scarcely a day passes without one or more; and at Comrie, in Scotland, so extraordinarily frequent are exhibitions of subterranean action, that in little more than two years not less than 247 shocks were noted and described. The opinion of Humboldt was, that if we were kept daily informed respecting the state of the whole surface of our planet, it would be found that its surface is nearly always shaking at some point or other of its circumference, and is subject to an uninterrupted reaction between the interior and the exterior.

In earthquakes of the intenser kind which have had their phenomena accurately examined, there is always an area indicated, often very circumscribed—perhaps the site of a town, a part of the open country, or a point at sea—where the concussion is the most violent, and is felt earlier than at distant places. This is the focus of disturbance. From such a spot the shock is propagated mechanically through the rocky crust of the earth, as sound travels through the air, to a distance which depends upon the strength of the impulse and the capacity of strata to resist or yield to vibration. The propagation is conducted in one of two different ways. In some instances the shock travels in a determinate direction towards certain points of the compass opposite to each other—north and south, east and west, as the case may be—affecting a comparatively narrow belt of intermediate country. This is called a *linear* earthquake, and is common in mountainous districts. In other cases, the shock extends somewhat equally on all sides from the focus, like rays from the sun, or the cracks in a square of glass when sharply struck by a stone; and its progress is comparable to that of the ring-like wave formed by a pebble on the surface of still water, which becomes weaker as the expansion increases. This is called a *central* earthquake. A striking example of this was furnished by the great convulsion at Lisbon, in the last century, which extended its waves of vibration to the Alps, the north of Europe, the West indies, and the shores

of Africa. When there is a series of shocks, protracted through several weeks or months, the centre often changes its place; and two or more *foci* have been observed. It is a curious but well-authenticated fact, that, after being propagated a certain distance, a shock may be intermitted through a considerable district of country, and be again manifest in a region lying beyond it. It is as though a barrier to progress had been met with, and overcome by an undermining process. On such occasions the earthquake is said, in the language of the South American Creoles, to form "a bridge"—the bridge being the intervening unaffected district, beneath which the shock is supposed to dip and pass onward at too great a depth to be sensible at the surface.

The nature of the motion communicated to the surface by earthquake-shocks is of several distinct kinds, distinguished by the terms tremulous, horizontal, vertical, undulating, and rotary. But in some instances the movement is so complex as to defy description.

The *tremulous* motion of the ground—*tremblement de terre* of the French, and *tremblores* of the South Americans—is more or less observed in all earthquakes, and is the least dangerous movement. The sensation produced is similar to that felt on board a steamer, when, in letting off the steam, the vibrating plates of the boiler cause the deck to tremble. Though walls are sometimes split by these tremors, and objects thrown down, they are not dreaded by the people of countries where they are of almost daily occurrence, life and property being generally secure. The *horizontal* motion seems to be really a vigorous expression of the tremulous. The surface strongly oscillates to and fro, is moved forward and backward, and often causes the actual displacement of objects. The *vertical* or upheaving shock is far more to be dreaded than either of the former, though it often occasions only an uplifting of the surface, which subsides again without fracture or any injury to the objects upon it. This kind of shock generally occurs when the tremulous movement is at its height. It is frequently accompanied with a loud explosive noise, and makes an impression upon the inmates of dwellings as if a blow had been struck at the foundations with some enormous hammer. This is familiarly known at Comrie as the "thud." Shocks acting in a perpendicular direction were experienced during the great Lisbon earthquake. This upheaving movement sometimes signalizes its activity with fearful violence. The ground is burst open. Houses are hurled from their sites. Trees, stones, and human beings are blown high into the air, as if some immense magazine of combustibles in the bowels of the earth had suddenly exploded. In many cases, probably in most, an *undulating* motion of the surface is produced as the effect of combined horizontal and vertical movements, by which objects are moved upwards and forwards, and then brought back to their original position. The appearance of the ground corresponds to that of a gentle swell of the sea. Whirling or *rotary* movements of the surface are rare, and are only observed in connection with the most desolating earthquakes. They are apparently caused by two or more horizontal shocks crossing each other at right angles. They are evidenced by walls being twisted round without being prostrated, and by the deflection of parallel rows of trees, and parallel ridges in the fields, as results of the vorticose or whirling motion.

The "General Catalogue of Earthquakes," which has been compiled for the British Association by Mr. Mallet, extends over a period of 3456 years, and is a wonderful monument of research. It furnishes evidence that the interval from the sixtieth to the eightieth year of a century is always the epoch of the greatest subterranean activity. Without accepting these limits as precisely determined, it is certain that there are cycles embracing a series of years when the forces in the interior of the earth acquire more than usual intensity, and display their power by producing volcanic eruptions and destructive earthquakes in regions widely remote from each other. These cycles comprise a greater or less number of the middle years of a century.

It is a well-established result of home and foreign observation, that earthquakes are preceded and accompanied by barometrical depression, indicating the diminished pressure of the atmosphere. Hence the occurrence of the greater number in the winter months, when the average height of the barometer is always the lowest, and is also subject to greater fluctuation than in the opposite season of the year. It may therefore be considered as highly probable, that while the causes of earthquakes are still shrouded in mystery, they are intimately connected in their occurrence with atmospheric changes. When the barometer is at 31 inches, the atmosphere presses on the surface of Great Britain with a weight equal to 291,793,239,406 tons. When it sinks to 27 inches, there is a diminution of weight on the same area equal to 37,648,938,386 tons, being about 427,231 tons to the square mile. Hence it may well be the case, that when the subterranean forces have acquired such strength as nearly to rupture the confining strata, any considerable diminution in the pressure of the atmosphere may bring on the crisis of actual disengagement.

It remains for future seismologists to note the course of events, and accumulate further evidence on the conditions and causes of these subterranean movements.

ALGEBRA.—CHAPTER III.

DIVISION.

Division has the same object in algebra as in arithmetic. It is in every way the reverse of multiplication. In multiplication we take a certain number, a certain number of times; in division we find how often a certain number is contained in another number. It is an operation which enables us to discover one of the factors of a given product when the other factor is known. From this definition it follows that the quotient multiplied by the divisor ought to reproduce the dividend, *e.g.* $6x \div 3 = 2x$, and $2x \times 3 = 6x$.

In applying this fundamental idea to the division of simple quantities, we perceive that the dividend being formed of the factors composing the divisor and the quotient, the latter must be that quantity which is left when the divisor is included in the dividend. For instance, to divide ab by a; here the dividend ab is composed of a, the divisor, and another factor, b; and this last, namely b, agreeably to our definition, is the quotient of ab divided by a; and b may be found by simply cancelling a the divisor, in the dividend ab.

We might reason in a similar manner respecting any other example of the same kind; we conclude accordingly that to effect the division of a simple quantity, where there has been already a multiplication by the quantity which is made the divisor, we must cancel in the dividend all the factors which compose the divisor, and the remaining part of the dividend will give the quotient sought. Thus

abc divided by a is bc; by b is ac; by c is ab;
abc " ab is c; by ac is b; by bc is a.

The rule obviously comprises numerical coefficients. This is shown in some of the following instances:—

Dividend.	Divisor.	Quotient.	Dividend.	Divisor.	Quotient.
$4abcd$	$2ac$	$2bd$	$15abbccd$	$abbccd$	15
$10aabdd$	$5ad$	$2abd$	$15aaxxx$	$5axx$	$3ax$
$12aappx$	$6app$	$2ax$	$2abbxxy$	$4axxy$	$\frac{1}{2}bb$
$2abbccdd$	$abcd$	$2bcd$	$2\frac{1}{2}aaaa$	$\frac{1}{2}aaa$	$5a$

In an extended arithmetical sense, which considers a *time* as well as *times*, any quantity admits of division by any other. Thus 9 contains 6 a time and half a time; or the quotient of 9 divided by 6 is $1\frac{1}{2}$. The appellation *divisible* is nevertheless applied, not to any quantity as compared with any other, but only as compared with such quantities as are contained an exact number of times in the quantity proposed for division. Thus 9 is said to be divisible by 3, and not divisible by 6. Or, by *divisible* is meant, that the division can be effected without introducing fractions into the result. In this sense ab is not divisible by ac; for the dividend ab does not contain the factor c, which is found in the divisor. But since the quotient, whatever it may be, is not altered when the dividend and divisor are both multiplied or both divided by the same quantity—that is, since $ma \div mb$ is the same as

$a \div b$—we conclude that $ab \div ac$ is the same as $b \div c$, which is conventionally written $\frac{b}{c}$ and is called the quotient of ab divided by ac; in other words, ab contains ac as many times as $\frac{b}{c}$ contains 1. And again, since the quotient multiplied by the divisor must reproduce the dividend,

$$\frac{b}{c} \times ac = \frac{abc}{c} = ab.$$

To divide, when the divisor is not exactly contained in the dividend, we must cancel all the factors which are common to the divisor and the dividend, and write the remaining parts in the form of a fraction as the quotient sought. Of course, when we have to divide one quantity by another which has no common factor, we must just indicate that the operation of division is to be performed, and that is done by placing the terms in a fractional form.

For example, to divide $12abcd$ by $8acdx$; here $12abcd = 4acd \times 3b$ and $8acdx = 4acd \times 2x$; therefore

$$12abcd \div 8acdx \text{ is the same as } 3b \div 2x = \frac{3b}{2x},$$

or $\frac{12abcd}{8acdx} = \frac{4acd \times 3b}{4acd \times 2x} = \frac{3b}{2x}$, the quotient sought.

Similarly, $6a^2xy \div 3abx$ gives, when we strike out the factor $3ax$, $\frac{2ay}{b}$.

$$6ab^2c^3 \div 4a^2bc = \frac{3bc^2}{2a}.$$

It does not follow, however, as one might be ready to imagine, that a quantity, because it has the fractional form $\frac{a}{b}$ is (arithmetically considered) a fraction; or that a quantity, because it has the integral form ab, is (arithmetically considered) a whole number. Letters are employed, in algebra, to represent quantities generally, and therefore they represent fractions as well as whole numbers. An expression which, considered algebraically, is fractional, may be, considered arithmetically, integral, and *vice versâ*. For instance, if $a = \frac{2}{3}$ and $b = \frac{1}{6}$, then $\frac{b}{a} = \frac{2}{3} \div \frac{1}{6} = 4$; and $ab = \frac{2}{3} \times \frac{1}{6} = \frac{1}{9}$. Similarly, if $a = 12$ and $b = 6$, then $\frac{a+b}{a-b} = \frac{12+6}{12-6} = \frac{18}{6} = 3$. When therefore we speak of fractional and integral quantities, we mean only that the symbols have these forms.

The following are examples of the foregoing rule:—

Dividend.	Divisor.	Quotient.	Dividend.	Divisor.	Quotient.
$2abbdd$	$2abcdd$	$\frac{b}{c}$	$21ppqq$	$42mnpq$	$\frac{pq}{2mn}$
$12axxyy$	$6aaxyz$	$\frac{2xy}{az}$	$amnxx$	$2amnxxy$	$\frac{1}{2y}$
$15abcd$	$10aadd$	$\frac{3bc}{2ad}$	$63abcd$	$7aacdd$	$\frac{9bc}{ad}$
$5anppq$	$10ampqq$	$\frac{np}{2mq}$	$12avvxx$	$8avyxxy$	$\frac{3v}{2y}$

Let it now be required to divide $ma - mb + m$ by m; that is, to find the quantity which, multiplied into m, gives $ma - mb + m$. Now, we know from what we were taught at p. 250, that $m\,(a - b + 1) = ma - mb + m$; consequently $a - b + 1$ is the quantity sought. But $a - b + 1$ is the expression $ma - mb + m$ with the common factor m struck out of every term. Therefore, adopting the fractional notation, we have

$$\frac{ma - mb + m}{m} = \frac{ma}{m} - \frac{mb}{m} + \frac{m}{m} = a - o + 1.$$

In this example the symbols employed are general, and therefore we conclude that the rule for the division of a compound expression by a quantity of one term is as follows:—Divide every term of the dividend by the divisor (as before) and connect the partial quotients by their proper signs, as in the analogous case of multiplication at p. 250. The following are instances in which the division can be effected without introducing fractions into the quotient.

Dividend.	Divisor.	Quotient.
$27abb + 3abx - 12aab$	$3ab$	$9b + x - 4a$
$12aab - 16abc - 4ab$	$4ab$	$3a - 4c - 1$
$7axxy - 14xxxy + 7xxyz$	$7xxy$	$a - 2x + z$
$3am - 6aamm - amn$	$3am$	$1 - 2am - \frac{1}{3}n$
$12abbc - 32bcxx - 4abcy$	$4bc$	$3ab - 8xx - ay$

If the terms of the dividend are not severally divisible by the given divisor, we must treat them as fractional forms. For instance, $ax + by - cz$ divided by xyz is,

$$\frac{ax + by - cz}{xyz} \text{ or } \frac{ax}{xyz} + \frac{by}{xyz} - \frac{cz}{xyz} \text{ or } \frac{a}{yz} + \frac{b}{xz} - \frac{c}{xy}.$$

The division here is not completed; it is only reduced to a series of more simple divisions. The following are instances of the same kind:—

$$\frac{aabb + 4aab}{aabb} = 1 + \frac{4}{b} \qquad \frac{a + b + c}{abc} = \frac{1}{bc} + \frac{1}{ac} + \frac{1}{ab}$$

$$\frac{3abc - 6bcd}{3abcd} = \frac{1}{d} + \frac{2}{a} \qquad \frac{xx + yy + 1}{xy} = \frac{x}{y} + \frac{y}{x} + \frac{1}{xy}$$

$$\frac{3axxx - 6aaxx + 6aaax - 3aaaa}{6aaxx} = \frac{x}{2a} - 1 + \frac{a}{x} - \frac{aa}{2xx}$$

$$\frac{4a + 4b - 3c + 2cd + 5dd}{2abcd} = \frac{2}{bcd} + \frac{2}{acd} - \frac{3}{2abd} + \frac{1}{ab} + \frac{5d}{2abc}$$

$$\frac{21ax + 7aaxy + 14xxy + 35axyz}{7axyz} = \frac{3}{yz} + \frac{a}{z} + \frac{2x}{az} + 5$$

$$\frac{ab + bc + cd}{abcd} = \frac{1}{cd} + \frac{1}{ad} + \frac{1}{ab} \qquad \frac{a - 1}{aa} = \frac{1}{a} - \frac{1}{aa}$$

$$\frac{xx + 4xy - yy}{4xxy} = \frac{1}{4y} + \frac{1}{x} - \frac{y}{4xx} \qquad \frac{a - aa}{aa} = \frac{1}{a} - 1$$

We have as yet considered only obvious cases of division. There still remains the more complicated case requiring the division of one compound expression by another: for instance, the division of $aa - 2ab + bb$ by $a - b$. The principle of this operation, however, is essentially the same as that already established in the preceding cases. The rule may be stated and illustrated in this way:—Taking the above example, we observe that the first term, aa, of the dividend $aa - 2ab + bb$ contains a, the first term of the divisor, a times; we therefore conclude that a times $(a - b)$, that is, $aa - ab$, must be a part of the dividend. Let that part be subtracted from the dividend; that is, let

$$(aa - 2ab + bb) - (aa - ab) = -ab + bb.$$

Now the first term of this remainder again contains a, the first term of the divisor, b times; we therefore conclude that b is another term of the quotient, and as ab has the negative sign, we further conclude from the rules for the signs in multiplication, that b ought also to be preceded by this sign: hence b times $(a - b)$, that is, $ab - bb$ with all its signs changed (because b has the subtractive sign $-$), ought to be a part (in this case, as it happens, the whole) of the remainder $-ab + bb$; that is,

$$(-ab + bb) - (-b)\,(a - b) \text{ or } -(-ab + bb) = 0.$$

As we now have nothing remaining, we conclude that $a - b$ is the quotient; that is, that the given dividend, $aa - 2ab + bb$, is the square or second power of the given divisor, $a - b$.

This process is in every respect analogous to "long division" in arithmetic, and it is commonly written in the same manner; *e.g.*

$$\frac{aa}{a} = a \qquad \frac{-ab}{a} = -b$$

Divisor.	Dividend.	Quotient.
$a - b)$	$aa - 2ab + bb$	$(a - b$
	$aa - ab$	
	$-ab + bb$ = first Rem.	
	$-ab + bb$	
	0 = second Rem.	

The rule may therefore be more specifically given thus:—(1) Arrange the terms according to the powers of some one

letter (in this case according to the powers of a); (2) inquire how often the first term of the divisor is contained in the first term of the dividend (*e.g.* how often a is contained in aa); and (3) write down the result (a) as the first term of the quotient; (4) multiply the whole of the divisor by that term, and subtract the product (namely, $aa-ab$) from the dividend; and (5) write down the remainder of the dividend (or as many terms of it as the case may require); then repeat the operation in the same way till all the terms of the dividend are exhausted. The whole dividend is thus, in reality, divided into so many parts by the process, and each of these contains the product of the divisor and a simple factor.

The divisor and dividend must be arranged, as has been said, according to the powers of some one letter (either ascending or descending) otherwise the quotient will not be found in its simplest form, and possibly the division will not be effected in finite terms, as may be easily seen if we change the order of the foregoing example, thus:—

$$\begin{array}{r|l} -b+a)\ bb-2ba+aa\ (-b+a \\ +bb-ba \\ \hline -ba+aa \\ -ba+aa \\ \hline \end{array} \qquad \frac{+bb}{-b}=-b \qquad \frac{-ba}{-b}=+a$$

Here the operation is in effect the same as before, but it illustrates another important fact regarding the signs, namely, that bb being divided by $-b$ gives for quotient $-b$, and that $-ba$ divided by $-b$ gives for quotient $+a$; that is, the signs of the dividend and divisor being alike, the sign of the quotient is $+$; and the signs of the dividend and divisor being different, the sign of the quotient is $-$. This, it will be remembered, is the rule which obtains in multiplication (p. 250).

If the terms of our example be written down without attention to the order of the letters, we may apply the rule thus:—

$$\begin{array}{r} a-b)-2ab+aa+bb\ (-2b+a+b \\ -2ab\qquad +2bb \\ \hline aa-bb \\ aa-ab \\ \hline ab-bb \\ ab-bb \\ \hline \end{array}$$

But we know that this quotient $-2b+a+b=a-b$: the process is therefore correct (as before), but less simple. A further derangement of the terms may render it impossible, abiding strictly by the rule, to effect the division at all. Thus by taking the divisor $a-b$ and arranging the dividend in the order $bb+aa-2ab$, we get for quotient

$$\frac{bb}{a}+a+\frac{bbb}{aa}-\frac{bbbb}{aaa}-\frac{bbbbb}{aaaa}-\text{\&c.}$$

Should it be found that a division cannot be effected, the quotient will be completed at any term by adding to the terms found, a term formed by writing the remainder over the divisor in the form of a fraction, as in the following case,

$$\begin{array}{r} x-4)x^2-6x+13(x-2 \\ x^2-4x \\ \hline -2x+13 \\ -2x+\ 8 \\ \hline 5 \\ \hline x-4 \end{array}$$

The student may verify the answer of the next example by actual division.

$$\frac{aa+4ab+4bb+c}{a+2b}=a+2b+\frac{c}{a+2b}.$$

He may also verify the following by the rule, namely,

$$\frac{aaa-bb}{a-b}=aa+ab+b,$$

$$\frac{aaaa-2aabb+bbbb-cccc}{aa+bb+cc}=aa+bb-cc,$$

$$\frac{yyy-1}{y-1}=yy+y+1,$$

$$\frac{1}{1-x}=1+x+xx+xxx+xxxx+\frac{xxxxx}{1-x}.$$

The student should try to work such instances as the following (which are of very frequent occurrence) at sight:—

$$\frac{6aa-9ax}{2a-3x}=\frac{3a\,(2a-3x)}{(2a-3x)}=3a,$$

$$\frac{4ab-2ac}{6ab-3ac}=\frac{2\,(2ab-ac)}{3\,(2ab-ac)}=\tfrac{2}{3},$$

$$\frac{aa-xx}{a+x}=\frac{(a+x)\,(a-x)}{(a+x)}=a-x,$$

$$\frac{aa+2ab+bb}{a+b}=\frac{(a+b)\,(a+b)}{(a+b)}=a+b,$$

$$\frac{xx-9}{x+3}=x-3, \qquad \frac{49-xx}{7+x}=7-x,$$

$$\frac{(6aa+6ab)-(8ax+8bx)-(9ay+9by)}{a+b}=6a-8x-9y.$$

We shall return to the investigation of the division of one compound expression by another, but this will be much more easily proceeded with when the student has acquired some knowledge of the nature of fractions. Only, if the fundamental principle of division be well studied, what has been here explained of the mode of conducting such operations will generally be found sufficient to enable the student to advance satisfactorily in all ordinary questions in division. He may now proceed to examine the mode pursued in working the following examples:—

(1) $2ab-3a^2b^2+5a^3b^3\div-ab=-\frac{2ab}{ab}+\frac{3a^2b^2}{-ab}-\frac{5a^3b^3}{ab}=$ $-2+3ab-5a^2b^2.$

(2) $-8ab^3c^5\div-12a^5b^3c=+\frac{2c^4}{3a^4}.$

(3) $18a^5b^3c\div6a^3b^2=3a^2b^3.$

(4) $54a^5b^3c^2mx^2\div-9a^3b^2c^2x=-6a^2b^3mx.$

(5) $24a^2x^2y-3axy+6x^2y^2\div-3xy=+8a^2x+a-2xy.$

The following examples may be verified by working:—

(1) $4a^2-10b^2\div2a-3b.$ Ans. $2a+3b-\frac{b^2}{2a-3b}.$

(2) $-16mx^3y+24nx^2y^2+56pxy^3\div-8xy.$ Ans. $+2mx^2-3nxy-7py^2.$

(3) $25c^2d^3e+40c^4d^3e^2f\div5d^2e+8c^2d^4e^2f.$ Ans. $5c^2d.$

(4) $11ab^2+6b^2+a^3+6a^2b\div a+b.$ Ans. $a^2+5ab+6b^2$

(5) $3x^4-4ax^3-12a^2x^2-7a^3x+a^4\div x-3a.$ Ans. $3x^3+5ax^2+3a^2x+2a^3+\frac{7a^4}{x-3a}.$

ASTRONOMY.—CHAPTER IV.

THE MOON, ☾—PERIOD—PHASES—EARTH-SHINE—HARVEST MOON—HUNTER'S MOON—MOON'S MOTIONS—LIBRATION—IRREGULARITIES IN MOON'S ORBIT—MOON'S SURFACE—LUNAR MOUNTAINS—SEAS—CRATERS—VOLCANIC NATURE—LUNAR ATMOSPHERE—LUMINOSITY—CALORIFIC RAYS—MOON'S MASS.

THE moon, as the satellite which revolves round our earth, is to us the most important of the secondary planets. The moon passes round the earth from west to east, but its path is not a perfect circle, for it may recede from the earth a distance of 251,000 miles, or approach it to within 225,700 miles. Hence the excentricity of the moon's orbit is said to be 0·0549. Its apparent diameter, calculated geometrically, varies between 29′ 21″ and 31′ 31″; consequently it is the same as that of the sun, the diameter at mean distance being 31′ 5″. To the eye the apparent diameter of the moon varies considerably, according to its altitude above the horizon. The real diameter, as given by Mädler, is 2159·6 miles, and according to Wichmann 2162 miles. Recent measurements by Airy and De la Rue show that these values are too great, and that a correction of about 2″ or 2·15″ must be applied to the measure of visual diameter to allow for the exaggerated dimensions due to *irradiation* (see Natural Philosophy, *Light*). This correction is equivalent to a reduction of about

THE FULL MOON — ECLIPSES OF THE MOON — THE LUNAR ORBIT.

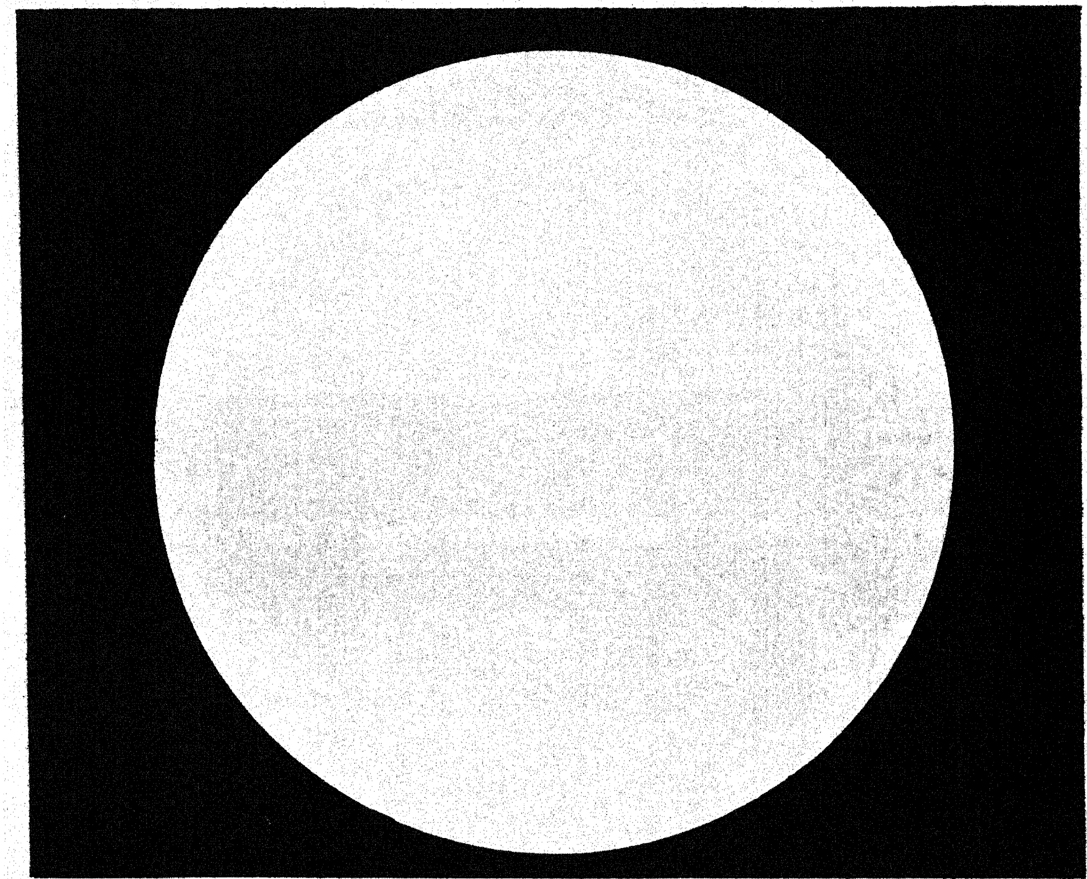


Fig 1. Telescopic view of the full Moon.

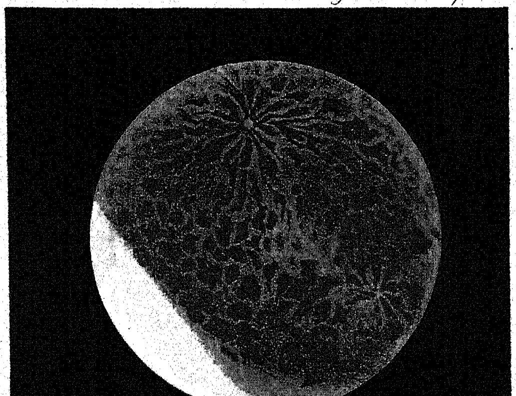


Fig. 2. Partial Eclipse of Moon.

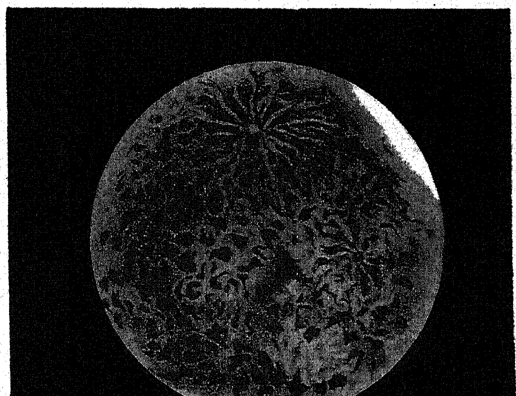


Fig. 3. Total Eclipse of Moon.

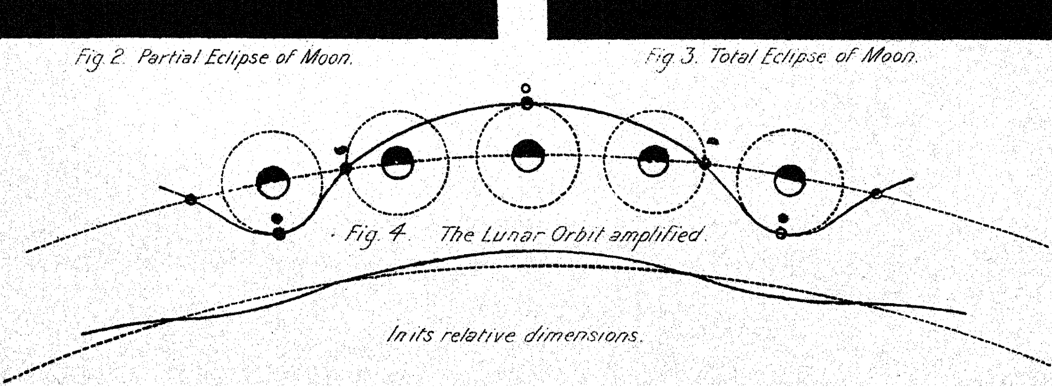
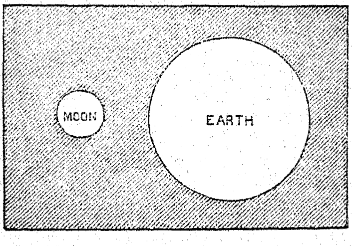


Fig. 4. The Lunar Orbit amplified.

In its relative dimensions.

2 miles. So far no compression on the sphere of the moon has been detected. It weighs, bulk for bulk, about two-thirds what the earth does, so that its total weight is only about one-eightieth of that of our globe, and the force of gravity at its surface will be only one-sixth of what it is on the earth. The relative sizes of the moon and earth are shown in the annexed figure.

The moon exhibits *phases* like the inferior planets. These depend on the different positions it assumes with respect to the earth and the sun, and they are due to different portions of its illuminated side being turned towards the earth at



different times. When the moon lies nearly in a line between the earth and the sun the dark side is turned exclusively to us, and for some time we lose sight of the moon (see Plate V., fig. 4). Then as it recedes from this line, its form appears as a faint crescent on the side of the disc next the sun, the rest of the disc being scarcely visible. This is the phase called *new moon*. When the moon has reached an angular distance of 90° from the sun, half of its disc is enlightened and it is said to be in its *first quarter*. After passing this point the "terminator," or line which divides the lighted from the dark portion of the moon, becomes concave towards the sun, and the moon is said to be *gibbous*. When it attains a distance of 180° from the sun the entire disc is illuminated, and the moon is *full*. It is then in "opposition" to the sun, rising about the time the latter sets. From this stage it passes to its *third quarter*, when only one-half of the disc is illuminated; and from this time until *new moon* it exhibits again the form of a *crescent*. These phases will be easily understood from fig. 4, Plate V., in which the moon is represented in the outer circle as it would appear to an observer placed at a distance from the earth, and in the inner circle as it appears when viewed *from* the earth.

For a short time, both before and after new moon, the outline of the unilluminated portion may be detected without much difficulty. This lustre is due to the light reflected on the surface of the moon by the earth, or "earth-shine." This light is stronger during the waning of the moon than at any other time, a fact which would seem to indicate that the western part of the lunar disc is on the whole better adapted for reflecting the solar rays than the eastern part; assuming this to be the case, an obvious explanation is furnished for the fact that the earth-shine is more luminous before the new moon than after it.

The *harvest moon* is the name given to that full moon which falls nearest to the autumnal equinox. As the moon then rises almost at the same time on several successive evenings, and at a point of the horizon almost precisely opposite to the sun, it is of much assistance to agriculturists at that important period of the year. Although this near coincidence in several successive risings of the moon takes place in every lunation when the moon is in the signs Pisces and Aries, yet the phenomenon is only prominently noticeable when it is full in these signs, which only occurs at or near the autumnal equinox, and when the sun is in Virgo or Libra. The explanation of the harvest moon is as follows:—Suppose the moon to be full on the day of the autumnal equinox; the sun is then entering Libra, and the moon Aries—the former setting exactly in the west, the latter rising exactly in the east; the southern half of the ecliptic is then entirely above the horizon, the northern half entirely below, and the ecliptic itself makes the least possible angle with the horizon. The moon is then advancing daily 13°, or one day's portion in its orbit, which is but slightly inclined to the ecliptic, and will become little depressed below the horizon, and has therefore a less hour-angle to traverse by the diurnal motion after sunset in order that it may come into view the next night, than at any other time. That harvest moon which occurs on 21st September is most favourable, the moon being then in the "ascending node" (to be presently explained) of her orbit, which then coincides with the vernal equinox. The moon next after the harvest moon is frequently termed the *hunter's moon*. The least possible variation between the times of two successive risings is about 17 minutes, and the greatest about 1 hour 16 minutes, which takes place when the moon is in Libra, and at the same time at or near its "descending node."

Of the various influences which the mass of the moon exerts, that which results in the phenomenon of the *tides* is the most important, and will be fully treated hereafter.

The motions of the moon are of a most complex description, and have occupied the attention of astronomers in all ages, but it is only within a recent period that they may be said to be fully understood. The moon is comparatively so near to the earth that its apparent movements are very rapid, so that by watching its progress on a clear night, it may be seen to move from star to star, changing its place perceptibly in a few hours. The period during which the moon makes an entire circuit of the heavens, from one star until it returns to the same star again, is called a *sidereal* or *periodical month*, and consists of about $27\frac{1}{4}$ days. The time intervening between one *new moon* and another is called a *synodical month*, and consists of nearly $29\frac{1}{2}$ days. The difference is due to the fact that while the moon is making one revolution round the earth, the sun has apparently been going forward in the same direction nearly one degree daily, hence the moon has to perform more than one complete circuit of the heavens in order to come up with the sun again, which determines the time of new moon, as will be understood from a reference to fig. 4, Plate V., where the relative positions of two successive new moons are shown.

The moon rotates on its own axis *once* during each of its revolutions round the earth, in consequence of which it always turns the same face towards the earth, with the exception of certain small variations at the edge which it is necessary to notice. A telescopic view of this face as seen at the time of full moon is represented in Plate VI., fig 1.

The moon's axis is very nearly perpendicular to the plane of its orbit, the deviation being only by an angle of 1° 32′ 9″; owing to this circumstance, and to the inclination of the plane of the lunar orbit to that of the ecliptic, the poles of the moon lean alternately to and from the earth. When the north pole leans toward the earth somewhat more of the region surrounding it is visible, and somewhat less when it leans in the opposite direction. This variation is termed *libration in latitude*. The amount of displacement in this direction is 6° 47′.

Again, in order that the same hemisphere of the moon should be continually turned towards the earth, it is necessary not only that the time of the moon's rotation on its axis should be precisely equal to the period of its revolution in its orbit, but also that its angular velocity in its orbit should, in every part of its course, exactly equal its angular velocity of rotation on its axis. This is not, however, exactly the case, for its angular velocity in its orbit is subject to a slight variation, and in consequence a little more of its eastern or western edge is seen at one time than another. This phenomenon, discovered by Hevelius in 1647, is known as the *libration in longitude*; the extent of this displacement is 7° 53′. The total maximum libration, *as viewed from the earth's centre*, amounts to 10° 24′. From the circumstance of the diurnal rotation of the earth, the moon presents itself under somewhat different circumstances at its rising and setting, according to the latitude of the earth in which the observer is situated. As viewed in these different positions, it is seen under different aspects; and this gives rise to another phenomenon, the *diurnal libration*, the maximum value of which only amounts to 1° 1′ 24″. Arago calculates that the various librations enable altogether $\frac{57}{100}$ parts of the moon's surface to be observed, the portion always invisible amounting only to $\frac{43}{100}$ parts of the surface.

As already stated, the moon's path round the earth is not a perfect circle, but an *ellipse.* It has been found, moreover, that the regularity of its motion is subject to very numerous perturbations. The whole number of such irregularities is not less than sixty, but the greater part are so small as scarcely to require our attention. The more important of these irregularities are due to the action of the sun, which operates in two ways; first, by acting unequally on the earth and moon, and secondly, by acting obliquely on the moon on account of the inclination of its orbit to the ecliptic. If the sun acted equally on the earth and moon, and always in parallel lines, its action would only restrain them in their annual motion round the sun, and would not affect their actions on each other, or their motions about their common centre of gravity. But, because the moon is nearer the sun in one half of its orbit than the earth is, and in the other half is further from the sun, it follows that in one half of its orbit the moon is more attracted than the earth towards the sun, and in the other half less attracted than the earth. Now, if the motions of the earth and moon round the sun were destroyed so that they could both fall freely towards the sun, then if the moon was in "conjunction," that part of its orbit which is nearest the latter, it would be attracted more than the earth, would fall with greater velocity towards the sun, and so the distance between moon and earth would be increased. If the moon was in "opposition," that part of its orbit which is furthest from the sun, it is evident that it would be less attracted than the earth, and would fall with a less velocity and be left behind, thus again increasing the distance between earth and moon. If, however, the moon was in one of the quarters then the earth and moon, being equally attracted towards the sun's centre, would descend directly towards that point, and thus tend slightly to diminish their distance.

Now whenever the motion of the sun tends to increase their distance it practically diminishes their gravity towards each other, and when it tends to diminish their distance it increases their gravity. Hence, as in the conjunction and opposition, their gravity is diminished, and in the quadratures it is increased; this gives rise to corresponding variations in their distance from each other at these periods.

The *plane* of the moon's orbit is inclined to that of the ecliptic at an angle of 5° 8′ 45″, which is called the *inclination of the lunar orbit,* and it necessarily intersects the ecliptic in two opposite points, which are called the *nodes*—the *ascending node* being that in which the moon passes from the southern side of the ecliptic to the northern, and the *descending* the reverse. The moon's nodes constantly shift their position on the ecliptic from east to west, at the rate of about $19\frac{1}{3}$ degrees each year, returning to the same points once in $18\frac{1}{2}$ years. This fact is expressed by saying that "the nodes retrograde on the ecliptic," since any motion from east to west, being contrary to the sun's apparent course among the stars, is called retrograde. The line which joins these points, the *line of nodes*, is also said to have a retrograde motion. It is important to bear these facts in mind, as, when we come to treat of *eclipses*, it will be seen that they have a close connection with these phenomena. The *line of apsides* of the moon's orbit revolves from west to east through her whole course in about nine years. The "apsides" of an elliptical orbit are the two extremities of the longer axis of the ellipse, corresponding to the *perihelion* and *aphelion* of bodies revolving about the sun, or to the *perigee* and *apogee* of a body revolving about the earth. Therefore the moon's perigee, and of course the apogee, revolve, and the line which joins these two points revolves with them.

These are only a few of the irregularities that attend the motions of the moon. These and a few others were first discovered by actual observation, and have long been known, but a far greater number have been made known by following out all the consequences of the law of universal gravitation.

We have hitherto considered the moon as simply revolving round the earth, but it must not be forgotten that both bodies revolve round the sun, and are attracted by it much more powerfully than they attract each other. The effect of the combined motions of the moon round the earth and the sun is this—that the moon's actual path in space consists of a series of curves which are *always concave* toward the sun. This will be better understood by reference to figure 4 in Plate VI., which represents a portion of the earth's orbit during the period from one new moon to another. The actual path of the moon during the same period is represented by the black line in the second figure. This path may be compared to the line described by a nail in the rim of a wheel which is travelling along a road, and at the same time rotating round its axle.

In appearance to the naked eye the moon's disc presents a mottled aspect, which results from its surface being unequally reflective, owing to the presence of numerous mountains and valleys on its surface. That such do exist is evidenced in the shadows cast by the high peaks on the adjacent plains, when the sun shines obliquely (Plate VII. fig. 1). At the full phase these shadows disappear, the sun's rays then striking the moon's surface in a perpendicular direction. On observing the boundary line of the illuminated portion between the times of new and full moon, it will be seen to present a rough jagged appearance; this is caused by the sun's light first falling on the summits of the high elevations, the surrounding valleys and slopes being still in the shade. The surface of the moon's disc has been carefully mapped out, and most of the lunar mountains have received names. Over 1095 of these lunar elevations have been measured for altitude, several of which exceed 20,000 feet. Another noticeable feature in the topography of the moon is the *gray plains* or *seas*, probably analogous to terrestrial "steppes" and prairies. Although they are termed seas, it is only a name, as no water exists on the moon's surface. The most curious objects revealed by the telescope are the *crater mountains* (Plate VII. figs. 2, 3). These are evidently of volcanic origin, and usually consist of a basin with a conical elevation rising from the centre. In form they appear to be generally circular, but owing to the spherical form of the moon's mass, those in the neighbourhood of the limb or edge, being viewed obliquely, have apparently an elliptical contour. One of the most remarkable of these is Tycho, seen on the drawing of the full moon (Plate VI., fig. 1), from which radiating streaks go in all directions over the lunar surface. These streaks are a feature peculiar to the moon, for they run through mountains and valleys for hundreds of miles without reference to the obstacles in their way. Many of the lunar mountains, when viewed with a powerful telescope, show decisive marks of volcanic stratification, arising from successive deposits of ejected matter, and indications of lava currents streaming outwards in all directions may be traced; while the flat bottom of one crater, named Albatequius, is seen to be strewed with masses of rock, and the exterior ridge of another, Aristillus, is hatched all over with deep gullies radiating towards its centre. The moon is generally supposed to be without an atmosphere, though some affirmative evidence exists. Schröter considered that there was an atmosphere, and he estimated the height to be not over 5376 feet, and Laplace considered it to be more attenuated than the most perfect vacuum of an air pump. Schröter arrived at his conclusion on the ground that if the moon possessed an atmosphere the phenomenon of twilight would as a consequence take place, and he thought he observed when the moon exhibited a very slender crescent, a faint crepuscular light extending from each of the cusps along the unenlightened portion of the disc at a distance of 1′ 20″; its greatest breadth being 2″. He thence calculated the height of the atmosphere to be only 0·94″ or 5376 feet. The moon would describe this arc in less than two seconds of time, and to this circumstance is due the difficulty attending its direct detection during eclipses and occultations. Sir J. Herschel considered that no atmosphere existed at the moon's surface dense enough to cause a refraction of 1″, that is, having $\frac{1}{1980}$ the density of the earth's atmosphere. Both the astronomers Beer and Mädler considered that the moon had an atmosphere, but of very limited extent, owing to the smallness of its mass; and thought it not improbable that this weak envelope might sometimes, through local causes, condense itself—an idea which, if correct, would help to elucidate some of the conflicting details of occultation phenomena. The suddenness with which occultations of stars by the moon take place is generally regarded as a proof that no lunar atmosphere exists.

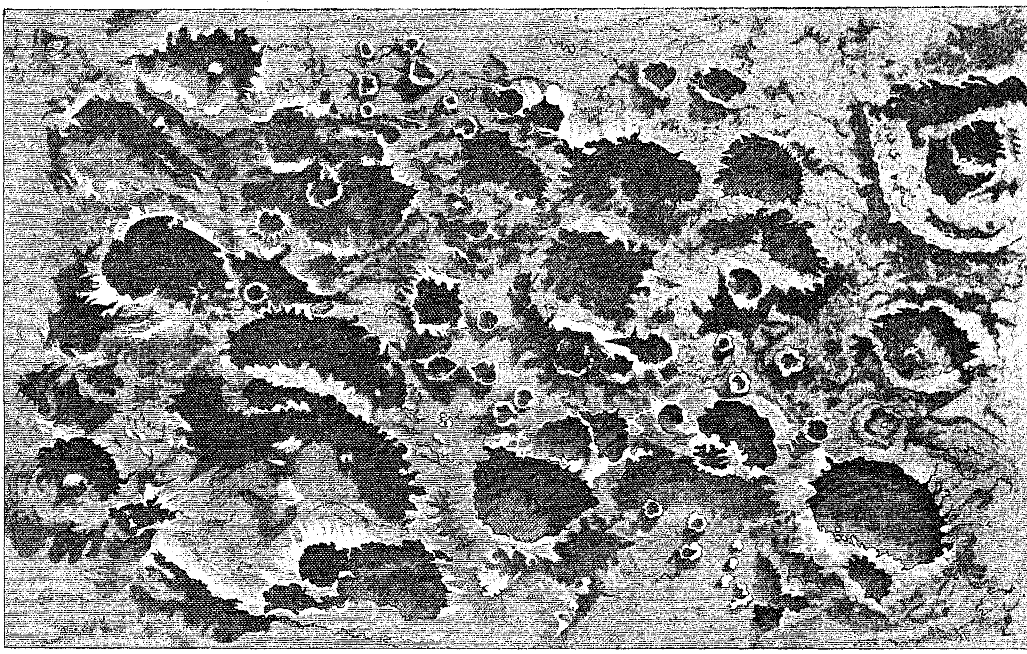


Fig. 1. Portion of the Moon's surface S.E. of Tycho.

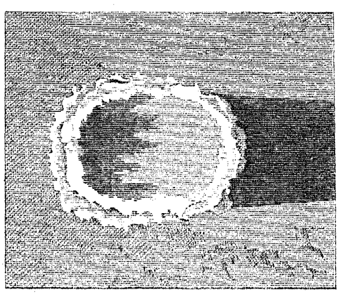


Fig. 2. Archimedes.

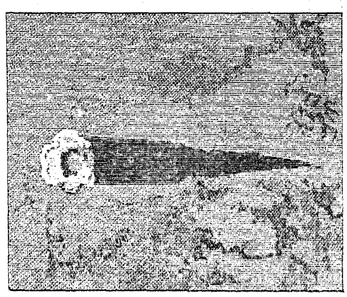


Fig. 3. Pico.

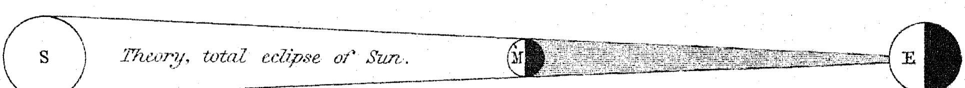


Fig. 4.

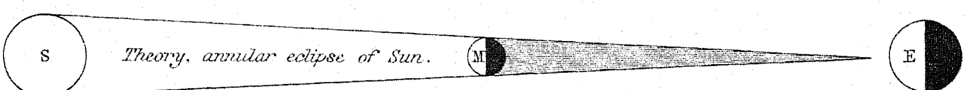


Fig. 5.

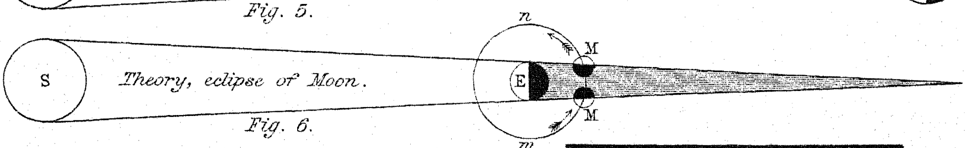


Fig. 6.

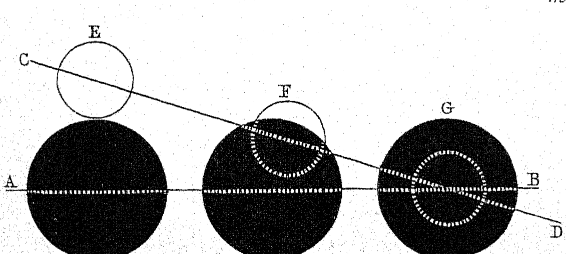


Fig. 7. Conditions of Eclipses of the Moon.

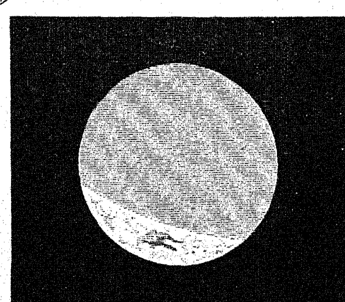


Fig. 8. Moon partially eclipsed.

and the spectroscope supplies negative evidence in the same direction.

As viewed from the sun, with the earth in perihelion and the moon in apogee, the moon never departs more than 10′ 42″ from the earth at its greatest elongation. The moon's axis being very nearly perpendicular to the plane of its orbit, it can experience scarcely any change of seasons. At its equator the mean solar day has a constant length of 354 hours 22 minutes, or 14 days 18 hours 22 minutes of mean solar time, or is equal to half the period of the moon's *synodical* revolution round the earth. As observed from the moon, some astronomical phenomena would be seen under widely different circumstances from those presented when viewed from the earth. The apparent diameter of the earth would be about 2 degrees, and its apparent superficial extent thirteen times greater than the apparent superficial extent of the moon as seen from the earth. The earth would appear almost a fixed object in the lunar heavens, only altering its place by the amount of the libration, or traversing backwards and forwards a space, having an extent of 15° 30′ in longitude and 13° 18′ in latitude. The earth again would exhibit to the moon exactly the same kind of phases which the latter does to the earth, but in a *reverse order*. When the moon is full, the earth would be invisible to the moon; and when the moon is new, the earth is full to the moon. These remarks of course only apply to those parts of the lunar surface which are turned towards the earth; a spectator on the opposite side would never view the earth at all, and a spectator placed on the apparent edge of the lunar disc would only now and then obtain a view of it in his horizon, due to the librations in longitude and latitude already noticed. The value of the moon's brilliancy is estimated by Bouger as only $\frac{1}{300000}$ that of the sun. The value according to Bond is $\frac{1}{470980}$, while Wollaston's value is only $\frac{1}{801072}$. The moon's surface is generally supposed to be at a considerable heat, possibly, according to Herschel, at a temperature exceeding that of 100° C. Notwithstanding this, the moon appears to radiate no heat available for warming the earth. Melloni in 1846 imagined that he detected a sensible elevation of temperature by concentrating the moon's rays in a lens 2 feet in diameter. Tyndall states that his experiments in 1861 indicated that the moon imparted to his thermometrical apparatus *rays of cold*. The more recent experiments of Earl Rosse and Marié-Davy appear, however, to give conclusively affirmative results, and the balance of testimony tends to this view of the subject. For the purposes of mapping the moon's surface photography has of late years been employed by De la Rue, Rutherford, and others, with excellent results. For computing the places of the moon very accurate tables were formulated in 1862 by Hausen, and have been introduced at the *Nautical Almanac* Office. The recent determination by Stone gives the moon's mass as $\frac{1}{81 \cdot 36}$ that of the earth. With reference to the moon's influences on the earth, it has been observed that evening clouds at about the period of the full moon frequently disperse as the moon rises, and that by about the time it has reached the meridian a sky previously overcast will have become almost or quite clear. Humboldt states that this circumstance is well known in South America, and Arago confirms the theory when he shows that more rain falls about the time of new moon than at the time of full moon.

CHAPTER V.

THEORY OF ECLIPSES—DEFINITIONS—RESULT OF INCLINATION OF MOON'S ORBIT—RETROGRADE MOTION OF NODES OF MOON'S ORBIT—COINCIDENCE OF 223 SYNODICAL PERIODS WITH 19 SYNODICAL REVOLUTIONS OF THE NODE—NUMBER OF ECLIPSES THAT CAN OCCUR—ECLIPSES OF SUN MORE FREQUENT THAN LUNAR ECLIPSES—DURATION OF ANNULAR AND TOTAL ECLIPSES OF SUN—DEFINITION: TOTAL, ANNULAR, AND PARTIAL ECLIPSES—AMOUNT OF DARKNESS—LOWERING OF TEMPERATURE—BAILY'S BEADS—CORONA—APPEARANCE OF MOON DURING SOLAR ECLIPSES—ECLIPSES OF MOON—OCCULTATIONS.

THE phenomena of eclipses result from the interposition of some one celestial body between the earth and some other body. As the heavenly bodies are in constant motion, the direction of lines drawn from one to another will necessarily vary from time to time, and occasionally it must happen that three will come into the same right line. If one of the extreme bodies of the series of three in a line is the sun, then the middle or intermediate body will intercept the sun's light, and deprive the third or last body of the series, either wholly or partially, of the illumination which in the ordinary course it receives. Thus, if the earth is at one extremity of the line, and the intermediate body is the moon, then the moon will intercept the light of the sun at the distant end, either wholly or partially, and observers on the earth, situated in the common line of direction, will see the moon pass over the disc of the sun, as it enters upon or leaves the common line of direction. The phenomena resulting from such contingencies of direction and position are variously termed *eclipses*, *transits*, and *occultations*, according to the relative apparent magnitudes of the interposing and obscured bodies, and according to the circumstances attending the phenomena.

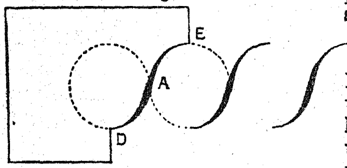
In considering the moon as the intermediary body between the earth and the sun, the circumstance that the moon's orbit does not lie in exactly the same plane as the earth's orbit, but is inclined to it at an angle which varies between 5° 20′ 6″ and 4° 57′ 22″, and for which 5° 8′ 45″ may be taken as the mean value, has to be taken into account. The two points where the moon's path intersects the ecliptic (as above explained) are called the *nodes*, and the imaginary line joining these two points is termed the *line of nodes*. If the moon passes through either node at or near the time of *conjunction* or *new moon*, it will come between the earth and the sun, and all three will be in the same straight line, and as a consequence, to an observer at certain parts of the earth's surface the sun's disc will be obscured, wholly or partially, as the case may be; this is an *eclipse of the sun*. In a total eclipse (fig. 4, Plate VII.), the moon's shadow reaches to and beyond the earth's surface, the moon being more or less in a perigean position; that is, at that part of her orbit which is nearest to the earth. In an annular eclipse of the sun, the moon's shadow falls short of the earth (fig. 5), the moon then being more or less in an apogean position, or in that part of her orbit which is furthest from the earth. As the earth and the moon are opaque bodies they cast shadows into space, and from the larger mass of the earth its shadow is considerably the greater of the two. If the moon should happen to pass through either node at or near the time of *opposition* or *full moon*, it will again be in the same straight line with the earth and the sun, but this time the earth will be between the moon and the sun, and therefore the moon enters the earth's shadow and is deprived of the sun's light; this is an *eclipse of the moon* (fig. 6, Plate VII.) Were the orbits of the earth and the moon in the same plane, an eclipse would happen at each conjunction and opposition, or about twenty-five times a year, but as the moon's orbit is inclined to the earth's at a mean angle of 5° 8′ 45″, eclipses are very much less frequent. The most recent investigations into the subject show that an eclipse *of the sun* may take place if the greatest possible distance of the sun or moon from the *true place* of the nodes of the moon's orbit is 18° 36′, whilst the *latitude** of the moon must not exceed 1° 34′ 52″. If the distance be less than 15° 19′ 30″, and the latitude less than 1° 23′ 15″, then an eclipse *must* take place, though between these limits the occurrence of the eclipse at any station depends upon the horizontal parallaxes and apparent semi-diameters of the sun and moon at the moment of conjunction. An eclipse *of the moon* may take place, if for the quantities above given 12° 14′, 9° 23′, and 63′ 45″, 51′ 57″, be substituted.

As the nodes of the moon's orbit are not stationary, but have a daily retrograde or backward motion of 3′ 10·64″, amounting in the course of the year to 19° 20′ 19·7″, a complete revolution round the ecliptic is only accomplished in 18*y*. 218*d*. 21*h*. 22*m*. 46*s*. nearly. This retrocession of the nodes on the ecliptic gives rise to the following circumstance:—The synodical period of the moon, or the time which she takes in passing from one

* *Celestial latitude* is the distance (reckoned in degrees, minutes, and seconds) of any body north or south of the *ecliptic*. It must not be confounded with *declination*, which is the distance north or south of the *celestial equator*. (See Plate I.)

therefore, adequate drill must be given to muscle and nerve in gaining power to accomplish this process readily and nicely. The best means known to us for securing proficiency in curvilinear exactness and grace is to construct a figure like that given on page 257, of the same size as the writing intended to be produced, and with this, placed on the left hand of the paper being written upon, used as a guide, proceed to form, at a uniform distance of three-fourths of an inch from each other, lines of like sinuosity of curvature along the whole width of the paper, and repeat the lesson till ease, readiness, and accuracy have been achieved. A simple and certain method of self-examination as to one's success in this course is available to everybody, thus :—Construct upon a card the geometrical figure on p. 257; having done so take a pair of sharp scissors and cut off the part of the card lying to the right of the double-curve and line D A E—snipping the card of course from the lower edge to D in a straight line with D C, and from the upper edge to E, in a similar straight line, continuatory of B E. The right edge of the card, thus cut, would show an outline like that given above (fig. 1), and would supply, if carefully and sharply cut, one great test of the accuracy attained in the formation of the caligraphic form of the Hogarthian line of beauty by simply applying the cut card edge to edge with the written line.

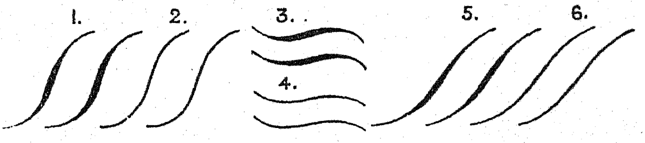
Fig. 1.



The main-stem grace-line of capitals, of which we have been speaking, ought to be three times the height of the small letters. In forming this line in the down-stroke movement, which is the most usual and the easiest, we begin with a fine hair stroke, at a height of three times that of the body of the minuscular writing we intend to make or are in process of making. The upper convex curve glides gently along through one and a half lengths, when it is transformed into a concave curve in the lower half. Upon the precise and elegant formation of this main-stem line the beauty of the letters of which it constitutes a chief part entirely depends. The slant must be taken in perfect harmony with the slope of the minuscules, the curves must be fluently and facilely contextured, and when a terminal oval is added it requires to be carefully kept in place and proportion, and must not be allowed to overweight the main-line too much. The body of the capitals ought rightly, one sees at once, to receive greater care than its mere accessories and ornaments; but this is too seldom attended to in common practice. Flourishes do indeed impart completeness of form to the letters and give satisfaction to the eye; they are therefore of very great importance to the elegance and acceptability of penmanship. As a general rule, however, they are left very much to the discretion of a writer, and constitute in ordinary copy-books the portion which gives least pleasure to the copyist. They occupy too large a place in the mind of the mere imitator, and are commonly spoiled with most pains-taking anxiety. These accessories, we should always remember, are mainly ornamental, and hence, unless done with a dexterous and easy grace, they lose the precise element which lends them charm. Signs of elaborate intention to give prettiness to a capital show that the excelling art which hides art has not as yet been obtained.

This grace-line appears in practical penmanship in several forms. The first and easiest is that which may be designated the down-stroke form. It commences at E (in fig. 1) in a fine hair-stroke, which in its convex curving course towards A gradually swells but does not bulge out into the normal thickness of stroke used in capital letters, and then in its concave curve from A to D insensibly tapers off into the tenuity of the terminal curve. The line must show no break of continuity, no abruptness of turn, no change of slope. The curves should shade sweetly and gently into each other, and, while the whole line ought to be perfect in form, it should also be pleasingly graded from commencement to finish. Persistent practice is required to attain facility in executing this peculiar form of curve-line. When it can be readily and properly performed by the mere gauge of the eye and the cultured

Fig. 2.



aptitude of the hand, the greatest difficulty in graphic manipulation has been mastered. The second or up-stroke form proceeds in the reverse order, beginning at D in a fine thin hair-stroke and continuing through A to E with a delicate steady selfsameness of stroke. In the third place we require to form the same grace-line horizontally, from left to right and right to left, and in all varying degrees of slopingness.

A little observation will then show how much has been accomplished by our practice in acquiring the power of forming this single element properly. We have been producing the main grace-line of many of the most beautiful and the most difficult of the capital letters (see fig. 2) :—(1) Those capitals of which the main element is a down-stroke grace-line, such as I, T, F, P, B, R, S, L, D, H, K, and J, to which add V and W; and (2) those in which the main element is an up-stroke grace-line A, N, M, with V and W, in which both forms of grace-line appear. These form seventeen capitals in all. The sameness of stem may easily be traced through all these letters as they are arranged in order from simplicity to complexity of form on Plate II.

Prior to proceeding to explain the method of forming the different capital letters *seriatim*, it will be necessary to notice that those several minute additions to or alterations of the main lines which we have called accessories require attention, as they tend to impart completeness, flowingness, and ease to the letters which they help to form. These may be classified as initial, medial, and terminal elements. They are, although necessary parts, not at all invariable. A large amount of freedom of choice and style is allowed in these minor, though far from unimportant matters. Some prefer an initial dot, some a final one. Some seek to lend graceful ornamentation by hair-stroke curves, both as commencing and terminating elements. These may vary somewhat in form, and several of them will be seen in Plate II.

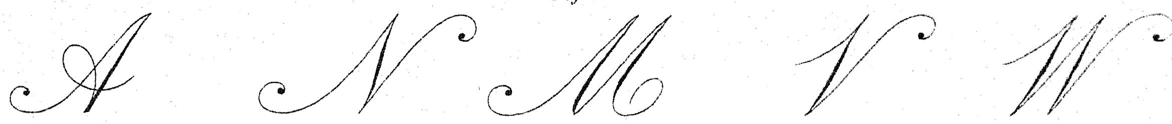
They ought to be practised as elements, so that the student may consciously see their proper place and use, and avoid giving to them an elaborateness which may overshadow and make seemingly subordinate the main-stem elements of penmanship. This is a very general, and in one sense a very natural error. They attract and gratify the eye. They are at once the pride of the dexterous wielder of the pen, and the plague of the laborious imitator who seeks to round off his letters with the sweet felicity of sweep with which each capital is adorned. They too often excite in the student despair of ever winning the ability to rival that wondrous curvilinearity of initial and final which adds witchery to graphic art. A collection of those accessories which are required to add completeness to the combinations of lines or curves employed in the formation of letters is given on Plate II. All those essential connections by which line is joined to line ought to be carefully and delicately made, and those should be chosen in each case which afford the neatest form with the readiest currency in junction. They should flow into and shade off from the main lines as if they were parts of them.

Plate II. exhibits a considerable number of those accessory parts—initial, medial or connective, and terminal—which can be most readily considered separately, practised sectionally, and explained easily; and we think we may best serve our readers by giving them those hints on their formation which seem most requisite now. They appear on the Plate in three lines. On the uppermost we have given three specimens of an accessorial terminal, such as occurs in N, V, and W, and is sometimes used as an initial in L and in the second line of K. Next we have an initial form which may be used in commencing H and K, T and F, V, W, and Z. These are dotted forms. The six succeeding elements are the same forms in

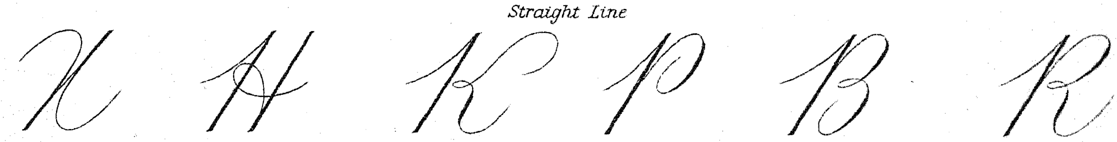
PENMANSHIP

CLASSIFIED FORMS OF CAPITALS

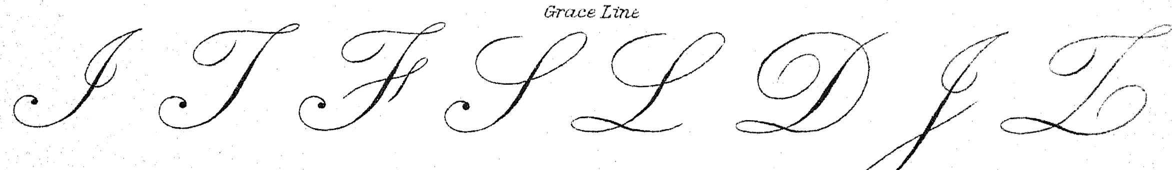
Angular



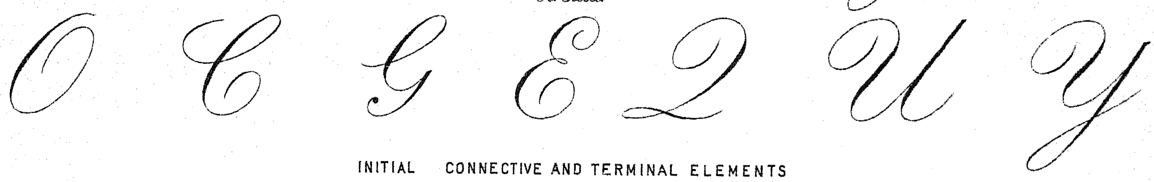
Straight Line



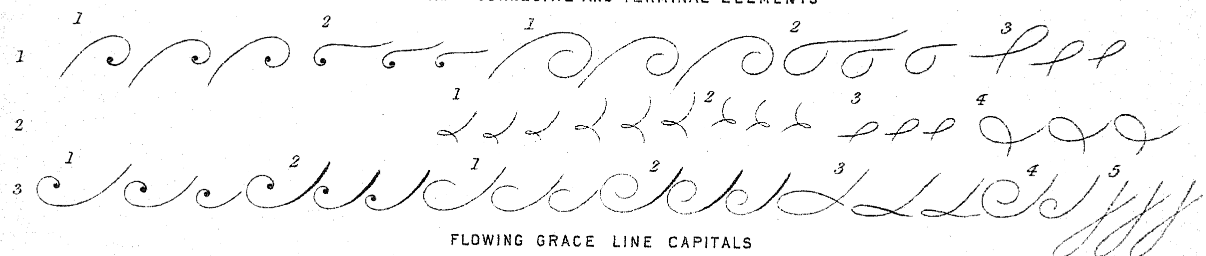
Grace Line



Circular

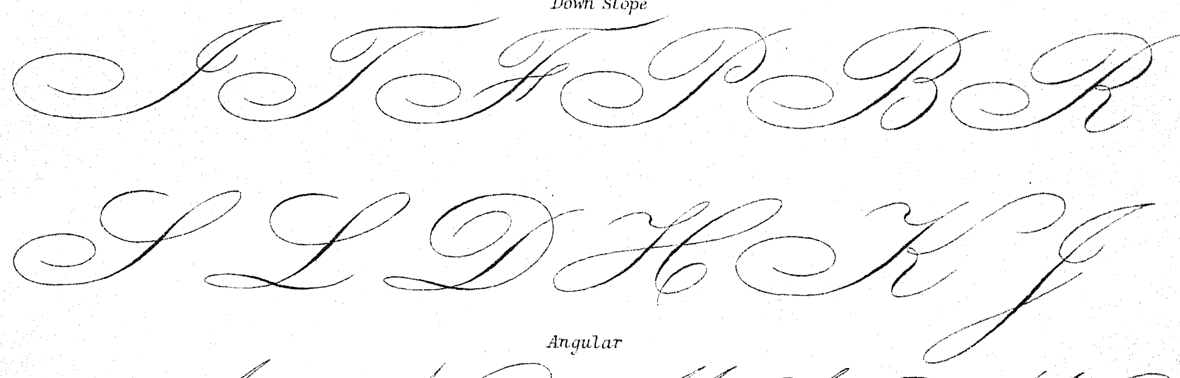


INITIAL CONNECTIVE AND TERMINAL ELEMENTS

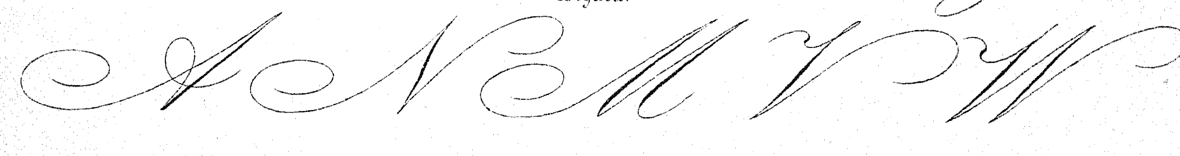


FLOWING GRACE LINE CAPITALS

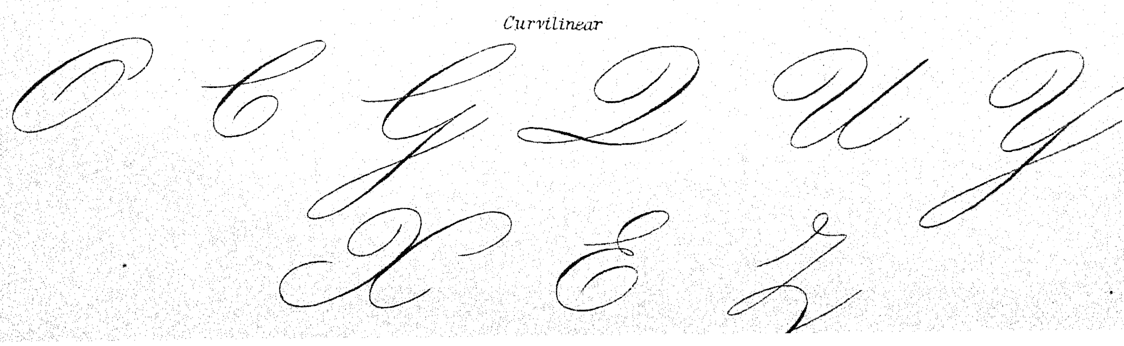
Down Slope



Angular



Curvilinear



ovalesque curves. The three last elements given on the top line are connectives, such as may be used in joining the main lines of I, T, F, H, K, G, Y, and Z, and with some enlargement may be used as parts of S, L, V, and W. In the middle line are given a few special connectives. The first six are specimens of medials, such as are employed in the formation of B, K, and R; the next three, of those which are used in E; the succeeding three occur as the crossing medial of F, and sometimes as the finals of M, K, H, R, and Z; and the last are commonly employed to unite the main lines of A and H, while they occasionally appear as initial in H, R, V, W, and Z. In the lowest line we have a dotted upward initial which requires great care. The first element is the *dot*. That is made perfectly circular and completely black, at about half a height from the base-line. After it has been made, the pen is to be swirled with an easy grace round the left-hand outer edge of it, and swept in a clear distinct curve into the main grace-stem of the letters in which it is used—A, N, M. Next we have a down-stroke dotted terminal, such as occurs in I, F, T, S, P, B, R, G, and some forms of K. The six specimens which follow are the same elements given as ovals. The first takes a sweep from right to left, beginning at the height of a small letter, swelling to half a height higher, and then, coming gradually round, fades into the curve of the upward-going grace-line stem, of which, in fact, it forms a part. The length of the oval is neatest when it occupies about a space and a half of that allotted to the small letters. The more distinctly oval it is the pleasanter it is to the eye, and the more gracefully does the letter commence. It is seen in A, N, M; is often used in V and W, and sometimes at the left-hand side of P, B, and R. The down-stroke form occurs as a terminal in the main line of those letters which have been named as taking a dotted final. The looped medial appears as the lower connective in D, L, Q, and Z. The terminal ovalesques which follow are employed in G, J, Y, and Z as tail-forms, when they terminate on the base-line, but the last three are the tail-forms given to these same letters when they are taken below the line.

All these forms should be studiously noted and carefully practised, and such familiarity in sweeping the pen along the course exemplified in the Plate ought to be gained, that no anxiety will be felt by the penman when he requires to introduce them in the capitals of which they form component parts. It will be a wise exercise of observation to note the different letters into which these elements enter, and to mark especially the manner in which they help in the formation of each compound capital. It may seem at first sight as if we were trying to make much of trivialities in asking so much care to be exercised on matters so small. The advantage of our teaching will appear hereafter. The effective success of the large evolutions of a great army depends on the care taken in the minor affairs which make up drill, and no magnificence of manœuvre can make up for the want of those neat junctions and admirable coadjustments which are brought about as the results of the skilful manipulation of men on the parade-ground. So ready and rapid, graceful and elegant penmanship depends on persevering drill of hand and eye, in the execution of those little movements which link the whole into unity, beauty, attractiveness, and legibility.

NATURAL PHILOSOPHY.—CHAPTER IX.

HYDRODYNAMICS—THE THREE FORMS OF MATTER—HYDROSTATICS — SPECIFIC GRAVITY — HYDROMETERS — SPECIFIC GRAVITY TABLES — SOLIDS — LIQUIDS — EQUALITY OF PRESSURE — WATER-LEVEL — SPIRIT-LEVEL — ARTESIAN WELLS — SAFETY VALVE — PRESSURE PROPORTIONAL TO AREA—HYDRAULIC RAM—ACCUMULATOR—PRESSURE PROPORTIONAL TO DEPTH—PRESSURE INDEPENDENT OF SHAPE OF VESSEL—PRESSURE ON BASE AND ALTITUDE—EQUILIBRIUM OF FLUIDS—CENTRE OF PRESSURE—PRESSURE UPON IMMERSED BODIES—PRINCIPLE OF ARCHIMEDES—EQUILIBRIUM OF FLOATING BODIES — METACENTRE — CARTESIAN DIVER—FISH BLADDER SWIMMING.

HYDRODYNAMICS is the science which treats of the pressure or weight and equilibrium of fluids under the action of forces, some of which are produced by fluids, and of the equilibrium of bodies immersed in them. It includes *hydrostatics* and *pneumatics*, which have reference to the laws of motion in their application to liquids and gases respectively.

All matter exists in three different conditions: the *solid*, the *liquid*, and the *gaseous* state, each of which exhibits distinct and characteristic properties. The two latter states, liquids and gases, are both included in the term fluid. The fundamental principles of hydrodynamics are governed by Newton's laws of motion, but as the mobility of the molecules of fluid bodies gives rise to important differences between the behaviour of fluids and that of solids under the action of external forces, it is more convenient to consider the former by themselves.

A *fluid* is a substance whose parts yield to any force impressed upon it, and the molecules of which are readily moved among themselves. The cause of fluidity in bodies is as yet undetermined, but has been supposed to depend upon the form of the molecules, on the modifications in their mutual attraction caused by temperature, or on both these circumstances combined; but whatever may be the primary cause, the property of fluidity is immediately dependent upon the more or less perfect mobility of the molecules among one another. This property of mobility distinguishes all fluids from *rigid* bodies, in which the molecules retain their relative positions and offer considerable resistance to any force tending to move them.

A solid body may be separated into two or more parts by the exertion of a certain amount of force or pressure—as in the act of cutting wood with a knife, or iron with a chisel—dependent upon the nature of the substance; but if a knife be passed through a mass of liquid, in the direction of its cutting plane, very little resistance will be offered, as the molecules of the liquid cohere so feebly together that a very slight force will separate them one from another. Again, a solid substance possesses a definite shape, which cannot be changed without the application of a certain amount of force; a fluid substance possesses no definite shape, but at once adapts itself to the form of the vessel in which it is contained. Fluid bodies therefore, under the action of gravity, cannot rest on a level surface without the assistance of lateral support, and cannot of course sustain any longitudinal pressure, however small, without the support of lateral pressure. A fluid may therefore be defined *as a substance whose molecules yield to any force impressed upon it, and by yielding are easily moved among themselves.*

Differences exist in the fluidity of different bodies; mercury and water are highly mobile, while the particles of other liquids, as oils, treacle, tar, &c., have a greater adhesion to one another. Such fluids are termed *viscous.* It is believed that all the non-elastic fluids, and probably also the gases, at certain temperatures lose their fluidity and congeal into a solid mass, as mercury, water, oil, &c., although certain liquids, as alcohol, ether, and carbon disulphide, have not yet been frozen.

Since the molecules of all bodies, fluid as well as solid, are separated by intermolecular spaces, it may be conceived that no fluids can be absolutely incompressible. Thus oil, water, and mercury, under enormous pressure, can be reduced in volume in certain degrees—those liquids which have the greatest specific gravity suffering the least compression. This diminution is, however, so small when compared with the volume of the fluid, that for all practical hydrostatic purposes liquids (as distinguished from gaseous fluids) may be considered as capable of no change of volume by the ordinary pressures to which they may be subjected.

The two great divisions of fluids are *liquids* and *gases*, and each again have their distinguishing properties. If a given quantity of water be placed in a vessel, it will occupy a certain space in the vessel, and no more, but if a small portion of hydrogen or other gas be introduced into an exhausted vessel, however large, the gas will expand so as to fill every part of the vessel; therefore, while a given quantity of liquid has a definite volume, but no shape, a given portion of gas has neither definite volume nor shape, its volume and form being always those of the vessel in which it is contained.

In hydrostatics, the units of measurement—*length, area, volume, mass*, and *time*—are the same as those for statics;

but to facilitate the solution of various problems and formulæ which follow, the following geometrical relations, which refer to the measurements of areas and volumes, are given.

The ratio of the circumference of a circle to its diameter $=3{\cdot}141592=\frac{355}{133}=\frac{22}{7}$ *about, and is expressed by the Greek letter* π.

The circumference of a circle $=2\pi r$, *where* r *is the radius of circle.*

The area of a circle $=\pi r^2$.

The area of a sphere $=4\pi r^2$. *The volume of a sphere* $=\frac{4}{3}\pi r^3$.

The area of the curved surface of a cylinder equals the product of the height into the circumference of the base $=2\pi rh$.

The area of the curved surface of a cone equals the product of the slant side into half the circumference of the base $=\pi r\sqrt{h^2+2^2}$, *where h is the height of the cone.*

The volume of a cone equals one-third of the volume of a cylinder on the same base and of the same height $=\frac{1}{3}\pi r^2 h$.

SPECIFIC GRAVITY.

Specific gravity is a term used to express the weight of any body in some given volume, as a cubic foot, a cubic inch, &c. Distilled water is the substance generally employed as a standard of comparison for the weights of all substances except the gases, and since the volume of every substance varies with its temperature, the weight has to be ascertained at one constant temperature. The specific gravity of a solid or liquid body is measured by the *ratio* of the weight of a unit volume of that substance to the weight of an equal volume of water at 4° C., which is taken as the standard. The specific gravity of gases is generally expressed by the ratio of the weight of a given volume of the gas to that of the same volume of air at 0° C., and 76 centimètres barometric pressure. When the specific gravity is considered as a ratio it is called *relative specific gravity*, while the weight of the mass of a unit of volume is the *absolute specific gravity*. Every body immersed in a fluid loses as much weight as an equal bulk of the fluid weighs. If, therefore, a body be of equal density with the fluid, say water, it loses all its weight, and requires no force but the weight of the displaced water to sustain it. If it be heavier its weight in the water will be the difference between its own weight and the weight of an equal bulk of water, and the force required to sustain it will be equal to that difference. If the body be lighter than water it will require a force equal to the difference of weights to keep it from rising in the water. The weights lost by immersing the same body into different fluids are as the specific gravities of the fluids, and bodies of equal weight, but different bulk, lose, in the same fluid, weights which are reciprocally as the specific gravities of the bodies, or directly as their bulks.

The weight of a body which will float in a fluid is equal to that of as much of the fluid as the immersed part of the body displaces when floating; hence the weight of the whole body is to that of the part immersed as the specific gravity of the fluid is to that of the body. And when the weight of a body taken in a fluid is subtracted from its weight out of the fluid, the difference is the weight of an equal volume of the fluid; this is to its weight in the air as the specific gravity of the fluid is to that of the body. Let therefore

W be the weight of a body in air,
w its weight in water or any fluid,
S the specific gravity of the body,
s the specific gravity of the fluid;

then $W-w : W :: s : S$, which proportion will determine either of those specific gravities, the one from the other; or $S=\frac{W}{W-w}s$, the specific gravity of the body, and $s=\frac{W-w}{W}S$, the specific gravity of the fluid. Consequently, dividing the weight in air by the loss of weight in water, the quotient is the specific gravity required. When two bodies of different specific gravities are mixed together to form one compound, the following are the equations denoting their weights and specific gravities.

H = weight of the heavier body in air, } S its shape in gravity;
h = " same in water,
L = " lighter body in air, } s its specific gravity;
l = " same in water,
C = " compound in air, } f its specific gravity;
c = " same in water,
w = the specific gravity of water. Then

$$(1)\ (H-h)\,S=Hw,$$
$$(2)\ (L-l)\,s=Lw,$$
$$(3)\ (C-c)\,f=Cw,$$
$$(4)\ H+L=C,$$
$$(5)\ h+l=c,$$
$$(6)\ \frac{H}{S}+\frac{L}{s}=\frac{C}{f}.$$

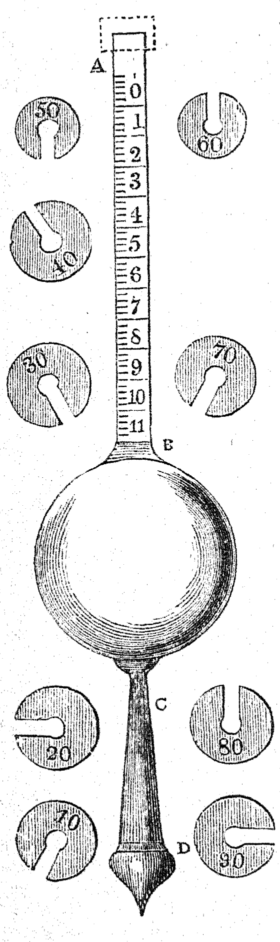
From these equations may be found any of the above quantities in terms of the rest. Thus from one of the first three equations is found the specific gravity of any body, as $s=\frac{Lw}{L-l}$, by dividing the absolute weight of the body by its loss in water, and multiplying by the specific gravity of water. Supposing the body L be lighter than water, then l will be a minus quantity, and the division will be by $L+l$ instead of $L-l$, and to find l recourse is had to the compound mass C; and as from the fourth and fifth equations, $L-l=\overline{C-c}-\overline{H-h}$, therefore $s=\frac{Lw}{(C-c)-(H-h)}$; that is, divide the absolute weight of the light body by the differences between the losses in water of the compound and heavier body, and multiply by the specific gravity of water, or $s=\frac{SfL}{CS-Hf}$, as determined by the last equation.

Again, if it is required to find the quantities of two ingredients mixed in a compound, the fourth and sixth equations will give their values as follows, $H=\frac{(f-s)S}{(S-s)f}C$, and $L=\frac{(S-f)s}{(S-s)f}C$, the quantities of the two ingredients, H and L, in the compound C.

In practice three methods are generally used to determine the specific gravity of solids and liquids; these are, the specific gravity flask, the hydrometer, and the hydrostatic balance. They all three depend on the same principle—that of first ascertaining the weight of a body, and then that of an equal volume of water. The *hydrometer* is an instrument for determining the relative densities or specific gravity of fluids, and is constructed upon the principle that when a body is immersed in a fluid it loses as much of its weight as is equal to the weight of that portion of the fluid which it displaces. If, therefore, the same body be immersed successively in two different fluids, the portions of weight which it will thereby lose will be directly proportional to the specific gravities of those fluids. As the weight of a fluid displaced by a floating body is constant—being always equal to the weight of the body, whatever may be the density of the fluid—it is obvious that from observing how much of the body is immersed, the specific gravity of the fluid may be determined, because when the weight is constant, the specific gravity varies inversely as the bulk. Upon this principle *Sykes' hydrometer* is constructed, which is universally employed in the assessment of the spirit revenue of Great Britain. It consists of a thin brass stem about 6 inches in length, passing through and soldered to a hollow ball of the same material, and about an inch and a half in diameter. To the bottom end of the stem, from which the hollow ball is about an inch removed, a pear-shaped weight is permanently attached, so that when the instrument is placed in a fluid the stem may float perpendicularly to the surface. The instrument is furnished with ten weights of different magnitudes, by the adjustment of which the instrument may be variously immersed so as to obtain the complete range of specif c gravity between pure alcohol and that of distilled water.

So accurately can the specific gravity of alcohol be determined by this instrument, that even the addition of a quart of water to 120 gallons of any spirit is immediately detected. The *common hydrometer*, invented by Fahrenheit in 1724,

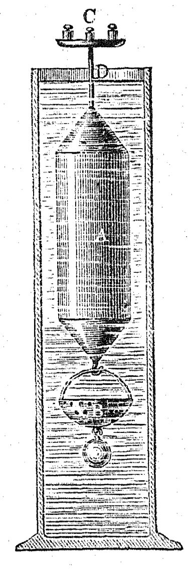
consists of a straight stem generally made of glass, which terminates in two hollow spheres. The lower and smaller of the spheres is weighted with mercury, so that the instrument may float in a perpendicular position. Let a = a section of the stem; W = the weight of the hydrometer, and v = volume of the instrument. If the hydrometer floats in water, assume that the stem is immersed to a point which is marked D, and that when placed in some other liquid the specific gravity of which is required, the stem is immersed to a point marked C. Then, if s be the specific gravity of the liquid, it follows $W = s(v - a \times AC) = v - a \times AD$, taking the weight of the unit-volume of water as unity, therefore $s = \frac{v - a \times AD}{v - a \times AC}$.



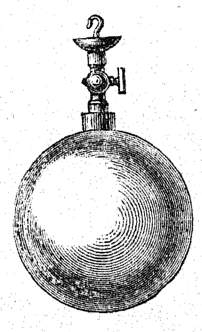
Sykes' Hydrometer.

Nicholson's hydrometer is a form of apparatus by which the specific gravity of solid as well as liquid bodies can be ascertained. It consists of a hollow metal cylinder, A, at the lower end of which is suspended, with the base uppermost to form a scale pan, a cone, B, loaded with lead to insure the vertical position in flotation; to the top of the cylinder a fine stem is attached which carries a small dish or pan, C, in which is placed the substance whose specific gravity is to be determined. On the stem a standard point, D, is marked. When the instrument floats in distilled water, with a certain weight, k, placed in the upper dish, it sinks to such a depth that the fixed mark D is on the surface of the water. When the specific gravity of a liquid is required to be determined, the instrument is placed in it, and the upper dish is weighted until the fixed mark D is on a level with the surface of the liquid. If W be the weight of the instrument, k the weight added to sink it to D in water, and w be the weight added to sink it to D in the given liquid, $W + k$ is the weight of the water displaced, and $W + w$ is the weight of the liquid displaced; and as the same bulk of fluid is displaced in each case, the specific gravity of the liquid is $\frac{W + w}{W + k}$. If it be required to find the specific gravity of a solid, let k be the weight that must be placed on the instrument to bring the point D on a level with the water. Place a small piece of the solid on the dish, and reduce the weight k so as to keep the instrument and the point D at the same level. Let m be the weight now employed, then $k - m$ = weight of the solid body. Let the substance, the specific gravity of which is to be found, be placed on the base of the lower cone or table, and on immersion a greater weight than m by the weight of the water displaced by the body must be placed on the upper dish to maintain the instrument in the same position. Let n equal the weight now in the dish; then $n - m$ = the resultant vertical pressure on the solid on the table of the lower cone = the weight of the water displaced by it. Therefore the specific gravity is $\frac{k - m}{n - m}$.

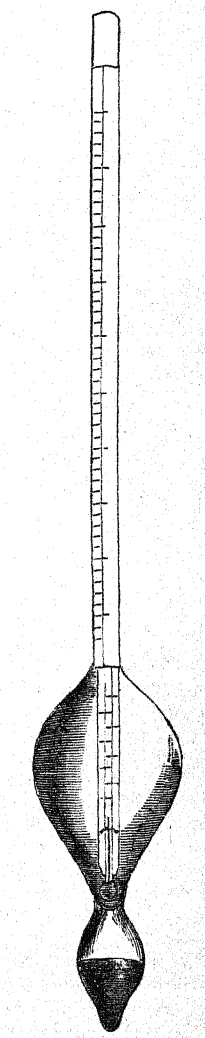
Perhaps one of the most convenient methods of obtaining the specific gravities of fluids is by means of what is termed *the specific-gravity bottle.* This is a bottle of a globular form, with an accurately fitted stopper, so adjusted as to contain exactly 1000 grains of distilled water at the temperature of 60° Fahr., and accompanied by a weight, which is an exact counterpoise for the bottle when thus filled. In order to determine the specific gravity of a fluid by this means, it is simply necessary to fill the bottle with that fluid at a temperature of 60 degrees, and place it, together with the adjusted weight, in the opposite scales of a delicate balance; then the number of grains which it will be found necessary to add to one of the scales, in order to produce equilibrium, will be the difference between the specific gravity of the fluid and that of water, taken at 1000. There are also other forms of hydrometers of *variable immersion but of constant weight.* The Beaumé hydrometer will serve as a type. It consists of a glass tube, loaded at the bottom with mercury, and with a bulb blown in the middle. The stem, the external diameter of which is as regular as possible, is hollow, and the scale is marked on it. The graduations of this scale differ according as the liquid for which it is to be employed is heavier or lighter than water. If employed for the denser medium, it is so weighted that it sinks in water nearly to the top of the stem, to a point which is marked zero. It is afterwards immersed in a solution of 15 parts salt to 85 parts water, and the point on the stem to where it sinks is again marked. The distance between these two points is divided into fifteen equal parts, and if necessary the graduation continued to the bottom of the stem. For liquids lighter than water a different scale



Nicholson's Hydrometer.



Specific-Gravity Bottle



Beaumé Hydrometer.

is employed, and the instrument is differently weighted. The graduation of the hydrometers is quite conventional, and they give neither the densities of the liquids nor the quantities in solution, but they are very useful in making solutions in given proportions, and in evaporating solutions to a given degree of concentration. *Lactometers* and *salimeters* are similar instruments. The lactometer is constructed on the knowledge that the average density of a good natural milk is 1·029. Therefore, if water is added to milk, it will indicate a lower specific gravity. As the density of milk, however, is increased by removing the cream, its specific gravity is increased, and if water is added to restore it to its proper density, the lactometer will not reveal the adulteration.

SPECIFIC GRAVITY OF IMPORTANT SOLID SUBSTANCES, WATER AT 4° C. = 1·00.

Platinum, cast,	20·86	Sulphur, native,	2·03
Gold, cast,	19·25	Ivory,	1·92
Lead, cast,	11·35	Graphite,	1·8 to 2·4
Silver,	10·47	Phosphorus,	1·77
Bismuth,	9·82	Magnesium,	1·74
Copper, hammered,	8·88	Amber,	1·08
Copper wire,	8·78	Anthracite,	1·80
German silver,	8·43	Coal, dense,	1·33
Brass,	8·39	Ebony,	1·33
Nickel,	8·28	Oak, English,	0·97 to 1·17
Steel,	7·82	Mahogany, Spanish,	1·06
Iron, wrought,	7·79	Box, French,	1·03
Iron, cast,	7·21	Wax, white,	0·97
Tin,	7·29	Sodium,	0·97
Zinc,	7·00	Potassium,	0·86
Antimony,	6·71	Beech,	0·85
Iodine,	4·95	Ash,	0·84
Heavy spar,	4·43	Maple,	0·75
Diamond,	3·25	Cherry-tree,	0·71
Flint-glass,	3·78 to 3·2	Walnut,	0·68
Aluminium,	2·57	Pitch-pine,	0·66
Bottle-glass,	2·60	Elm,	0·60
Plate-glass,	2·37	Cedar,	0·59
Marble,	2·84	Willow,	0·58
Emerald,	2·77	Larch,	0·54
Rock crystal,	2·66	Poplar,	0·38
Porcelain,	2·49 to 2·14	Cork,	0·24

LIQUIDS AT 0° C.

Mercury,	13·596	Tar,	1·015
Sulphuric acid,	1·848	Water, distilled, at 4° C.	1·000
Nitric acid,	1·500	Linseed oil,	0·940
Aqua regia,	1·234	Proof spirit,	0·930
Hydrochloric acid,	1·218	Olive oil,	0·930
Blood, human,	1·045	Ether, hydrochloric,	0·874
Ale, average,	1·035	Turpentine, oil of,	0·870
Milk,	1·030	Brandy,	0·837
Sea-water,	1·028	Alcohol, absolute,	0·796
Vinegar,	1·026	Ether, sulphuric,	0·720

PRESSURE OF FLUIDS.

It is one of the properties of inelastic fluids that they always seek to find their level; that is, if any part of the fluid be raised higher than the rest by the application of any force, and then left to itself, the raised portion of the fluid will descend by gravity until its surface is in equilibrum, and level with the other portion. This is illustrated by reference to figs. 8 and 9, Plate V. O and K are the two arms of a bent tube in communication with each other at N and M, and filled with a liquid. If external pressure is exerted upon the surface of the fluid in the arm K, the liquid will descend and rise in the arm O in the same proportion, but remove the pressure at K and the fluid in O will immediately descend and find its level at E D and A B. In fig. 9 the bent tube is immersed in a vessel, F G H L, filled with liquid, and if the liquid has access to the tube by a hole made at M, the fluid in the vessel, and the two arms of the bent tube, will be at the same levels, L F, A B, D E. This principle is often utilized in the laying on of water services to houses in cities and towns. The reservoir containing the water is constructed on ground at a higher elevation than the houses, and as the water in the pipes endeavours to rise up to the same level with the liquid in the reservoir, the supply is delivered to the houses without mechanical pressure, or forcing the water through the pipes and mains in the streets.

Another application of this property of an inelastic fluid always finding its level in communicating tubes is the *water-level*. It consists of a metal tube bent up at both ends, in which are fitted glass tubes. It is placed on a tripod stand, and water is poured into the tube until it rises in both the glasses. When the instrument is at rest the level of the water in both tubes is the same, and will be upon the same horizontal plane. When it is required to determine the difference of elevation between any two stations, A and B, a levelling staff is fixed vertically at B, and the observer looks at it through the level, keeping the two surfaces of the liquid in the tubes in a line; the levelling staff at B is then raised or lowered until the centre mark on the staff is in the same plane with the two surfaces of the liquid in the tubes. The height at B is then measured from the ground to the centre mark on the staff, and subtracting it from the height of the level the height of the station A is obtained.

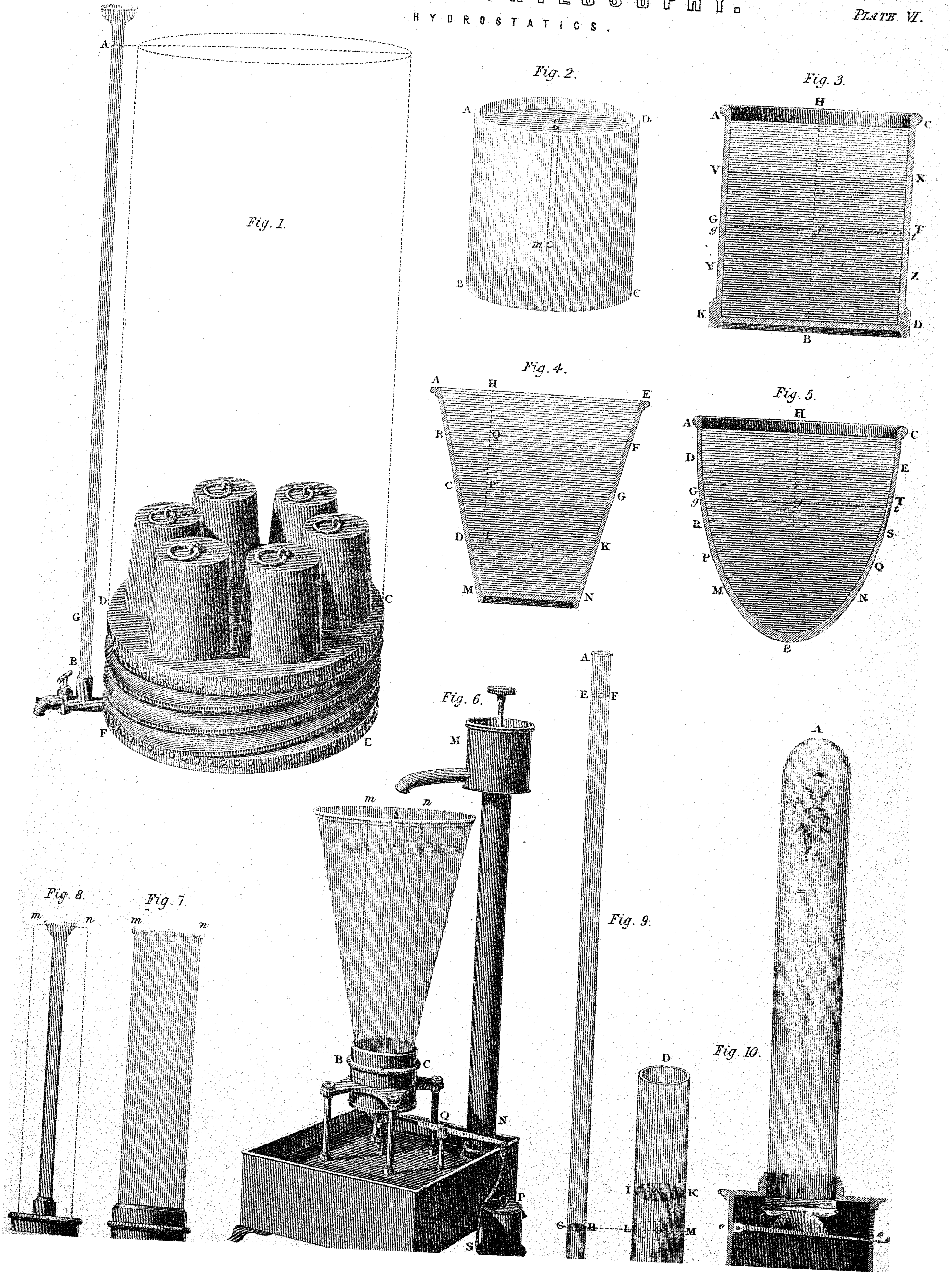
The *spirit-level* is a more accurate instrument than the water-level, and is based upon the same principle. It consists of a glass tube about 6 inches long, very slightly convex, and filled with spirits of wine, with the exception of a bubble of air, which always tends to occupy the highest part of the tube. The tube is fitted into a brass or wooden case, the bottom of which is a plane surface, and the tube is so arranged that when in a perfectly horizontal position the bubble of air will be equi-distant from the two ends of the case, and be exactly between two points marked on the case to indicate this position. When levels are taken with this instrument it is fixed on a mounted telescope, which can consequently be brought into the necessary position to place the air bubble in the horizontal position in the level. The rise of springs to the surface of the ground, the flow of rivers towards the sea, and the construction of *Artesian* wells, are all examples of the tendency of liquids to find their level. The flow of a spring is illustrated at fig. 7, Plate V. A and B are two underground reservoirs, or accumulations of water from the percolations of rain through the surface of the ground, and communicating with each other by the fissure D. The water by gravity forces its way through crevices C and F to the lower level G, where it issues forth as a spring. The Artesian well, which derives its name from the province of Artois in France, is dependent upon the drainage of water from higher elevations into a basin or area of greater or less extent, the geological formation of which consists of two impermeable beds of earth, such as clay, inclosing between them a permeable layer of sand, gravel, or other porous earth. The rain-water falling upon the part of this porous layer which comes to the surface on the higher elevations of the hills surrounding the basin, filters through it, and by the natural fall of the ground accumulates in the porous stratum in the hollow of the basin, whence it cannot escape by reason of the two masses of impermeable clay above and below it. If a well is therefore dug in the hollow of the basin, and reaches this porous stratum where the water has accumulated, the water will rise and spout up to a height which depends on the difference of the levels between the out-crop of the porous stratum on the distant hills and the point at which the well is sunk. Very frequently the water drainage which feeds Artesian wells is derived from sources of surface drainage some 60 or 70 miles distant, and the depth of the accumulation under the basin varies in different places. The celebrated Artesian well at Grenelle is 1800 feet deep, and supplies 656 gallons of water per minute. The temperature of the water is at the surface 27° C., and, on account of the increase of temperature with increasing depth below the surface of the earth, if this well were 210 feet deeper, the water would flow with a constant temperature of 32° C., the ordinary temperature of a warm bath.

All inelastic fluids possess the property of transmitting pressure equally in every direction, and any pressure exerted upon any point of their surface is so transmitted in every direction. When a fluid is pressed by its own weight, at any point, it transmits the pressure equally in all directions, be-

NATURAL PHILOSOPHY.

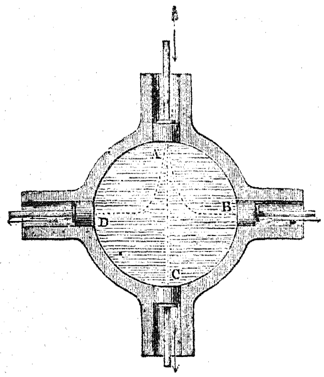
HYDROSTATICS.

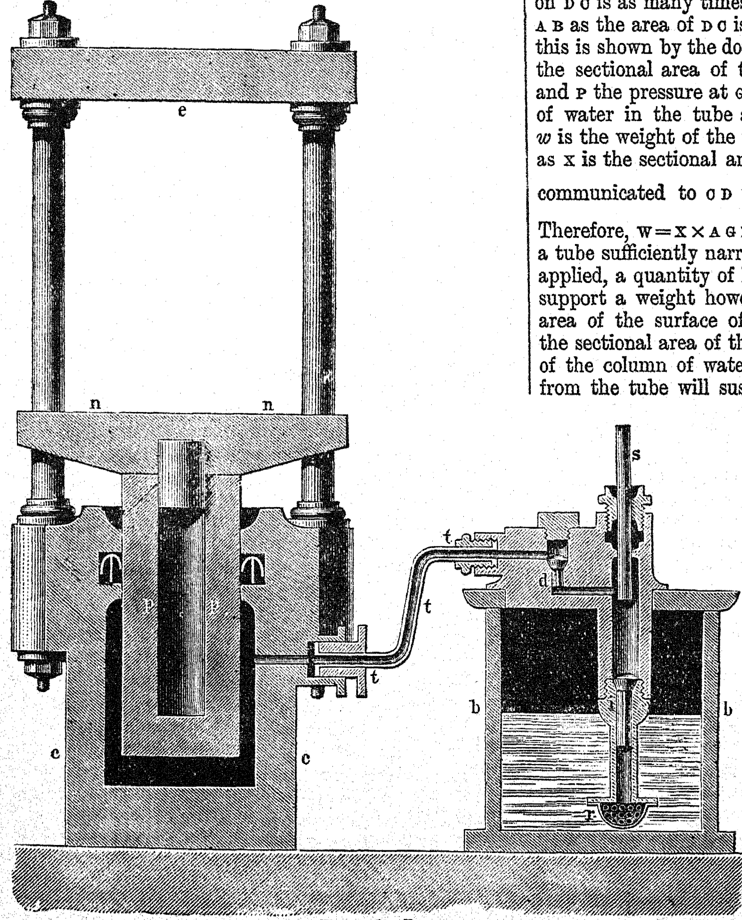
PLATE VI.



cause liquids are bodies whose molecules are displaced by the slightest force. This property is the fundamental principle of hydrostatics, and it may be resolved into two laws:—*The force exerted by a fluid on any surface with which it is in contact is perpendicular to that surface.* Thus the pressure exerted by the fluid against every part of the surface of the sides or bottom of the vessel containing it, whatever the shape, will, while the fluid is at rest, be perpendicular to the surface, as no force can produce motion in a direction perpendicular to its own direction; if it were otherwise the reaction of the surface could not entirely destroy that pressure, and some portion of it would disturb the equilibrium which is the condition of the fluid in the vessel. The second law, which is generally known as *Pascal's principle*, may be stated as follows:—*When a fluid is pressed by its own weight, or by any other force, this pressure is transmitted equally through the fluid in every direction.* This may be experimentally proved. Let B C D be three openings of equal area in a globe filled with water (see cut), kept closed mechanically by such a force as is necessary to balance the pressure of the piston at A. If any additional load be put upon this piston it will be found that the same amount of force must be exerted on the pistons B, C, and D to prevent them being forced outwards; and if the area of one of the openings be larger than the others, the amount of pressure which must be applied to the larger opening to keep it in equilibrium will bear the same proportion to the pressure applied at A that the area of the larger opening bears to the area of A. From this it follows that if a fluid be confined in an inclosed vessel, any pressure upon any area of the surface of the containing vessel will be transmitted equally through the fluid to every equal area in any other part of the vessel. It is this law which renders the safety-valve of the steam boiler reliable. Thus if the area of the valve on a boiler be one square inch, and the pressure of the steam be required not to exceed 75 lbs. on the square inch, which is the load on the valve, any excess of pressure beyond the 75 lbs. on the square inch of surface of the boiler will immediately open the valve, and it will remain open until the pressure of the steam is reduced to 75 lbs. on the square inch. The same principle, that any force acting upon the surface of a fluid is transmitted through the fluid equally in every direction, has been applied to multiply pressure; this is a sequence of Pascal's law. Let D C E F, fig. 1, Plate VI., be an elastic reservoir capable of rising as it is filled with water, B a tap from the bottom of the reservoir and carrying B A, a long vertical tube. If water is poured down the tube it will flow into the reservoir, and when a sufficient quantity has entered, the liquid in the reservoir and in the tube will stand at the same level, say G. Let the six weights be now placed upon the top of the reservoir, and additional water be poured into the tube A B, it will be found that a position of equilibrium will be maintained at, say, A. The pressure exerted by the column of liquid in the tube A B, above the level G D C, is sufficient to support the weights, as this pressure is communicated to every element of area on the surface of the reservoir D C equivalent to the sectional area of the tube A B, and therefore the whole pressure on D C is as many times greater than the weight of water in A B as the area of D C is greater than the area of the tube; this is shown by the dotted lines indicating the area. Let a be the sectional area of the tube, X the area of the reservoir, and P the pressure at G, produced by the weight of the column of water in the tube about it. Then $P = a \times AG \times w$, where w is the weight of the unit volume of water in the tube; and as X is the sectional area of the reservoir C D, the pressure communicated to C D will be $\frac{X}{a} \times a \times AG \times w = X \times AG \times w$.

Therefore, $W = X \times AG \times w$. From this it follows that with a tube sufficiently narrow, to the liquid in which a pressure is applied, a quantity of liquid, however small, can in principle support a weight however large. In the illustration, let the area of the surface of the reservoir be 336 square inches, the sectional area of the tube 1 square inch, and the weight of the column of water in the tube 1 lb., then 1 lb. pressure from the tube will sustain 336 lbs. on C D, which equals the amount of the weights, 3 cwts. It will easily be deduced from this, that if a pressure of 200 lbs. was exerted on the column of water at A, the pressure on the reservoir would be 200×336, or 67,200 lbs. This principle has been made use of in the construction of the Bramah press and other machines for exerting great force in raising weights, such as the hydraulic lift.





Hydraulic Press.

The hydraulic press (see cut) is an iron cylinder, *c c*, in which works the piston *p p*. Let *t t* be a small tube opening into the cylinder, and having a valve opening inwards. Let the cavity of *c c* be filled with water, as also a part of the small tube *t*; the pressure of a single pound applied at *s* to the piston-rod will produce a pressure upon *p p* which will be as the area of the end of the piston *p p* to that of the piston *s* in the forcing-pump.

If we suppose the diameter of the former to be 10 inches,

and that of the piston in the forcing-pump to be a quarter of an inch, then the proportion between the surfaces of the pistons will be that of 1600 to 1; and on the principle of the equal pressure of fluids in every direction, the force with which the piston *p p* is raised is to the resistance against the lower surface of that in the forcing-pump in the same proportion.

The action of the press is as follows:—The piston of a small forcing-pump is shown at *s*. When this piston ascends the water rises from the cistern *b* into the tube of the pump, shown in section, a rose *r* being fitted to the lower end of the tube to prevent extraneous matters from being drawn into the pump. When the piston descends it closes the valve *i*, and compresses the water strongly against it. The water, therefore, escapes by the tube *t*, and is forced into the cylinder. But when the piston rises again for the next stroke and the pressure is momentarily relaxed, the water cannot return because of the valve *d*. The piston *p p* rises with irresistible force, pressed upwards by the growing mass of water beneath it at each stroke of the forcing-pump. It is essential that it should work easily, but should be water-tight. This is effected by the ingenious collar of Bramah, one of the most important improvements in connection with the hydraulic press, which is so contrived that the greater the pressure, the firmer the grip of the collar upon the piston, by which means all leakage is avoided. It consists of a broad ring of leather, well saturated with oil, so as to be impervious to water. The edges of the ring are bent downwards so as to form in section a ∩. This is fitted into a groove in the neck of the cylinder, and being concave downwards, in proportion as the pressure increases, the more tightly is it pressed by the water against the sides of the piston and the neck of the cylinder, preventing any escape of water. Thus the plate *n n* rises towards the fixed plate *e*, and bales or goods placed between them receive the pressure required. The force-pump is worked by means of a lever handle, which increases the power in proportion as the pressure on *s* is augmented by the length of the lever. The hydraulic press is employed in compressing cotton, hay, cloth, paper, and bales of merchandise generally. It is also used for expressing oil from seeds, and bending thick iron plates, testing the strength of boilers, cannon, and chain cables. In the form of the hydraulic ram it exerts a driving force, used largely in important launches of great ships; or in another form it raises heavy weights, as instanced in the enormous tubes of the Menai Bridge raised by Robert Stephenson. The cylinder of the largest hydraulic ram used at the Menai Straits was 9 feet long and 22 inches in internal diameter; it was capable of raising a weight of 2000 tons.

When hydraulic machinery is employed to produce great power which is only required at intervals, such as for raising bridges, or the opening of dock gates, the traction of railway goods-trucks, working of cranes, &c., an *accumulator* is used. The piston or ram *p p* is heavily loaded, and the water is forced into the cylinder under great pressure by powerful pumps. From the bottom of the cylinder a tube conducts it to any place where the power is required to be applied, and the flow of a very small quantity of water will perform a great amount of work, so that if the large piston sinks only one-sixteenth of an inch, the flow of about a pint of water may represent an amount of work of over 1200 foot-pounds.

EFFECTS OF DEPTH ON PRESSURE OF FLUIDS.

All fluids are subject to the action of the force of gravity in the same manner as solid bodies, and as a fluid is supposed to consist of an infinite number of particles pressing downwards in a vertical direction, and exerting the same pressure in every direction, but which is counteracted by the equal pressure of all the surrounding particles, it follows that the pressure of any point within a heavy inelastic fluid at rest and not exposed to external pressure, is proportional to the depth of that point below the surface of the fluid.

Let *m* (fig. 2, Plate VI.) be a point at the depth *o m* below the surface of the fluid contained in the vessel A B C D. Suppose the fluid contained in the small vertical cylinder *o m* extending from the base *m* to the surface *o* to become a solid, then the forces acting upon this cylinder *o m* are (1) the fluid pressures on its curved surface, all of which are in a direction perpendicular to its axis; (2) the weight of the cylinder *o m*; (3) the fluid pressure on the base *m*, parallel to the axis.

The first has no tendency to produce motion in the direction of its axis, therefore there is no vertical motion. The fluid pressure on the base *m* is equal to the weight of the cylinder *m o*, and is therefore proportional to the height *m o*, or the depth of the point *m* below the surface. Any given mass of liquid in a state of rest in a vessel may therefore be conceived to be divided into innumerable horizontal sections or layers of the same density, and each layer will support the weight of those above it. Gravity therefore produces internal pressures in the mass of a liquid, which vary at different points below the surface. The effect of gravity may be stated as follows:—*The pressure in each layer is proportional to the depth, and with liquids of different densities the pressure at the same depth is proportional to the density of the liquid. The pressure is the same at all points of the same horizontal layer.* In figs. 3, 4, and 5, Plate VI., some of these assumed strata in the liquids contained in the vessels are indicated; thus the pressure on V X (fig. 3) will be as the depth A V; the pressure on the stratum G T as the depth A G, and so on. The increase of pressure, as the depth of the liquid is augmented, is indicated by the darker shading of the sections. Although the pressure exerted by a liquid on any part of the liquid, or on the sides of the containing vessel, depends on the depth and density of the liquid, *it is wholly independent of the shape of the vessel, and of the quantity of the liquid.* This law, which depends upon the equality of pressure, may be experimentally demonstrated. Let B C (fig. 6, Plate VI.) be a brass tube, the bottom of which is sustained in its place by the arm Q of the scale S, into which any weight, P, is placed to maintain equilibrium, or exert any additional force that may be necessary to overcome additional pressure placed upon it. A conical shaped glass is screwed upon the tube B C. A small pump, M N, is attached to the water-pan of the apparatus, by means of which the glass vessel is now filled with water to a certain height marked upon a vertical indicating rod fixed in the centre of the tube B C, and the weight P is so adjusted as exactly to counterbalance the weight or pressure of the liquid in the vessel. The conical glass being unscrewed, the cylindrical vessel, fig. 7, is attached by the screw or socket to B C, and also filled with liquid to the same height as the larger vessel, which is observed by means of the mark on the index rod, and it will be found that to keep the lower disc in its place exactly the same weight must be placed in the scale-pan as before. The same result will be obtained when the narrow tube (fig. 8) is placed on the tube B C. These results demonstrate that the pressure upon the lower plate of the tube is exactly the same in each case, and independent of the shape of the vessel or the quantity of liquid—the *base* of the vessel B C being the same in each case. The principle here enunciated proves that a very small quantity of water is capable of producing considerable pressures. Let an ordinary beer cask be filled with water, and insert a long tube tightly into the bung, if water be poured into the tube the pressure exerted upon the bottom and sides of the cask bears the same ratio to the weight of the column of water in the tube as the total area of the bottom and sides of the cask bears to the sectional area of the tube. By means of a narrow column of water 40 feet high Pascal succeeded in bursting asunder a very strong oak cask. It therefore follows that *the pressure of a fluid on the base of the vessel in which it is contained is as the base and perpendicular altitude, whatever be the figure of the vessel containing the fluid.* If the sides be upright, so that the vessel forms a prism or cylinder of uniform width throughout (fig. 3), then the base supports the whole fluid, and the pressure will be equal to the weight of the fluid it contains; because the fluid may be considered to be made up of innumerable vertical colums of fluid, and as each of these columns will pass vertically downwards with its weight, therefore the sum of these pressures will be the weight of the fluid, and the base being horizontal will sustain all these vertical pressures.

If the vessel containing the fluid be wider at the top than at the bottom (fig. 4), then the bottom sustains only a pres-

sure equivalent to a column of the fluid of which the base is the base M N of the vessel, because the other parts, as A M H, are supported by the sides of the vessel, and have no influence upon the column of fluid beyond keeping it in position by the lateral pressure upon its sides, as M H, which in no way affects its perpendicular pressure. The pressure therefore upon the bottom, M N, is *less* than the weight of the fluid contained in A M N E. If the vessel be wider at the bottom than at the top, the bottom will still be pressed with a weight which will be equal to that of a column of water of which the base is that of the base of the vessel. In this case, therefore, the pressure upon the base of the vessel *exceeds* the weight of the contained fluid. Consequently, in vessels of any figure, regular or irregular, upright or slanting, or with wide or narrow mouths, or variously wide and narrow in different parts, if the bases and perpendicular altitudes be the same, the bases always sustain the same pressure.

Therefore when the heights are equal, the pressures are as the bases; and when the bases are equal, the pressure is as the height; and when both the heights and bases are equal the pressures are equal, though the quantity of fluid may vary.

When several liquids of different densities are placed in the same vessel, it is necessary, to establish equilibrium, that they should be superimposed upon one another in *the order of their decreasing densities from the bottom upwards*, so that each liquid satisfies the conditions necessary for a single fluid. This can be illustrated experimentally by placing mercury, water saturated with carbonate of potassa, coloured alcohol, and petroleum in a narrow bottle. When the bottle is shaken the liquids will all mix, but allowing the bottle to rest the liquids will again separate and arrange themselves in the order of their respective densities. The mercury sinks to the bottom, the water comes next, then the alcohol, and then the petroleum (the water is saturated with carbonate of potassa to prevent mixing with the alcohol). This separation of the liquids is due to the same cause as that which enables a cork to float on water or a cannon ball on mercury. For the same reason the fresh water brought down, at the mouths of rivers, floats for a long time on the surface of the denser salt water of the sea. Cream floats on milk because, being less dense than the milk, it separates from it and rises to the surface. When two liquids of different densities which do not mix are contained in two communicating vessels, they will be in equilibrium when, in addition to the preceding conditions, they are subject to the following: *that the heights above the horizontal surface of contact of two columns of liquid in equilibrium are in the inverse ratio of their densities and in proportion to the areas of their bases.* This may be illustrated by taking a bent glass tube A B C D, (fig. 9, Plate VI.) The column of water E G, pressing upon the mercury at G H, lowers its level in the arm B G, and raises it in the other arm by the quantity N O; so that if, when equilibrium is established, a horizontal plane, G H O, is supposed to pass through G H, the column of water in G E balances the column of mercury O N. If the heights of these two columns are then measured, and the two arms of the tube were of *equal area*, it will be found that the height of the column of water is $13\frac{1}{2}$ times greater than the height of a column of mercury of the same area on the base, and as the density of mercury is nearly $13\frac{1}{2}$ times that of water, it follows that the heights are inversely as the densities. This principle may be deduced from a very simple calculation. Let d and d' represent the densities of water and mercury, h and h' their respective heights, and g be the force of gravity. The pressure on B will be proportional to the density of the liquid, to its height, and to the force of gravity, or therefore to the product $d\,h\,g$. Similarly the pressure on C, supposing it to be of equal area with B, will be proportional to $d'h'g'$, but to produce equilibrium $d\,h\,g$ must be equal to $d'h'g'$ or $dh=d'h'$; and as the products must always be equal, d' must be as many times greater than d as h' is less that h. From this the density of a liquid may be determined. Let one tube contain oil and the other water, and their heights be respectively 15 inches for the oil and 14 inches for the water. The density of water being taken as 1, and that of oil being represented by x, then $15 \times x = 14 \times 1$, and $x = \frac{14}{15} = 0{\cdot}933$.

When a plane surface is immersed in a fluid the pressures at different points of the surface are perpendicular to it, and constitute a system of parallel forces, the sum of which is the whole pressure. The point at which this pressure acts is termed the *centre of pressure*, and is *the point of action of the single force equivalent to the whole pressure exerted by a fluid on any plane surface with which it is in contact.* When a plane surface is immersed horizontally the *centre of pressure* corresponds with *the centre of gravity*, but this is not the case if the plane surface be immersed in any other position, because then the pressure upon equal areas varies as the perpendicular height of the column of fluid, and the different elements of area over the whole surface are at different depths below the surface of the fluid. The centre of pressure, or the point in the plane surface which is the resultant of the sum of these forces, does not correspond with the centre of gravity of the surface. The centre of pressure in any surface subject, like the side of a vessel containing a fluid, to the hydrostatic pressure of the fluid, is that point at which a force, being applied in a contrary direction to that of the pressure, will keep the surface in equilibrium; and when the surface pressed is symmetrical on each side of a line joining the centres of gravity and pressure, the latter coincides with the centre of percussion in mechanics. When a triangle in a vertical position is pressed by a fluid, its vertex coinciding with the surface of the fluid, and its base being horizontal, the distance of the centre of pressure from the vertex is equal to three-fourths of the perpendicular of the triangle. If the triangle have one of its sides in the surface of the liquid, the depth of the centre of pressure will be half that of the apex immersed; because if the triangle be divided into a number of narrow horizontal strips, the pressure on each strip acts at its middle point, and consequently the whole pressure on the triangle will act somewhere in the medium line drawn through the middle point of the side in the surface of the liquid. As, however, the pressure on each strip is proportional to its area multiplied by its depth, the value of this product is constant for every pair of strips at equal distances from the middle point of the medium line. Consequently the resultant pressure acts at the middle point of this line, or the depth of the centre of pressure is half that of the apex immersed.

When a body is wholly immersed in a fluid every point of its surface is subjected to a pressure perpendicular to the surface at that point. Now, as all these pressures can be resolved into horizontal and vertical components, and since the horizontal pressures balance each other, the resultant pressure must be vertical, and act downwards or upwards. Again, as the pressure varies with the depth, the sum of the pressure on the lower half of the body will be greater than that on the upper half, and therefore the resultant of all the pressures on an immersed body is a force acting vertically upwards. This force is termed the *resultant vertical pressure.* When a symmetrical body with vertical sides is wholly immersed in a fluid, the magnitude of this resultant pressure is readily obtained. The downward pressure upon the body exerted by the fluid is equal to the weight of the column of fluid having its upper surface for a base, whilst the upward vertical pressure is equal to that of a column having its lower surface for a base, therefore the resultant vertical pressure will be equal to the difference between the weight of these two columns, or to the weight of a column of fluid equal to the distance between the upper surface and lower surface of the body, which is the weight of the fluid displaced.

When the body is of irregular shape, a more general method of proof is adopted. Let the body to be immersed be supposed to be a portion of the fluid itself solidified; if no change of density takes place, the solidified fluid will remain as before, in equilibrium. Therefore, the weight of this portion of the fluid, which acts, at its centre of gravity, vertically downwards, is counterbalanced by the upward pressure of the fluid; and the resultant vertical pressure equals the weight of the solidified fluid. But as the fluid would exert exactly the same pressure on any other body occupying the same space in the fluid, the resultant vertical pressure on any body immersed is equal to the *weight of the fluid displaced*, and acts at its centre of gravity, which point is termed the centre

of displacement or *centre of buoyancy*. This principle is known as the *principle of Archimedes*, who discovered it about 250 B.C. It may be briefly stated as follows:—*When a body is immersed in a fluid, it is subject to the resultant pressure of the fluid on the surface of the body, which is equal to the weight of the fluid displaced, and which acts at the centre of buoyancy vertically upwards.* Consequently when a body floats in a fluid, in order to bring its upper surface level with that of the fluid, it must be loaded with a weight equal to the difference between the weight of the body or of the displaced fluid, and the weight of a volume of the fluid equal to that of the whole body. The weight which a floating body will thus sustain is termed the *buoyancy of the body;* and on this principle depend the ordinary rules for the computation of the buoyancy of vessels, rafts, mooring buoys, caissons, &c. If a solid body float in equilibrium in a fluid the centres of gravity of the body and of the displaced fluid must be in one vertical line, otherwise the upward pressure of the fluid below, which necessarily has its resultant in a vertical line passing through the centre of gravity of the place occupied by the body, would produce in the body a rotatory motion. This circumstance has given rise to three distinctions in reference to the equilibrium of floating bodies. (1) If the centre of gravity of the body be *below* that of the displaced fluid, the body is said to possess a *stable* or firm equilibrium; (2) if the centre of gravity be *above* that point, the body is said to float with *unstable* equilibrium; (3) if the centres of gravity exactly *coincide*, the body will float in any position, and is said to be in *neutral* equilibrium. Whether a floating body, partly immersed, can suffer a partial displacement without being capsized is a matter of immense practical importance, as the safety of all vessels at sea depends on it. Owing to the action of the tides, wind, and waves, a vessel rarely floats in perfect equilibrium, but is continually undergoing a rotatory displacement which causes it to roll and oscillate about its original position. It has been already stated that when the centre of buoyancy is above the centre of gravity of the ship, it will always return to its original position of equilibrium, and the vessel is stable; but when the centre of gravity of the ship is above the centre of buoyancy the vessel is very likely to overturn if displaced, and hence arises the danger of overloading with deck cargoes, which raise the centre of gravity of the vessel higher and higher, and also the advantage of ballast in lowering the centre of gravity of the vessel. As when a body floats in equilibrium the centre of gravity of the body and the centre of buoyancy lie in the same vertical line, if the body receives a slight displacement, the centre of buoyancy assumes a new position, on which the stability of equilibrium mainly depends. When a vertical line is drawn through this new position of the centre of buoyancy, the point where it intersects the line drawn through the two centres of gravity when in a vertical position, is called the *metacentre* of the body, and its position depends on the shape of the body and on its centre of gravity. If the centre of gravity of the body be below that of buoyancy, the metacentre will be above the centre of gravity. Consequently the equilibrium of a *floating body is stable or unstable, according as the metacentre is above or below the centre of gravity of the body;* and the metacentre may be defined as the point in which the vertical through the centre of buoyancy of a floating body which has undergone a slight displacement intersects the line drawn *vertically* through the centre of buoyancy in the original position of equilibrium. If a body floats *wholly* immersed in a fluid, no change in the position of the body will alter the relative positions of the centres of gravity and buoyancy, but to obtain stability the centre of gravity must be *below* the centre of buoyancy. If the positions be reversed, the slightest oscillation will cause the body to overturn. The various effects of suspension, immersion, and flotation, can be reproduced by means of the well-known toy, the *Cartesian diver* (fig. 10, Plate VI.), which consists of a glass tube or cylinder nearly filled with water, and closed at the bottom by a cover of sheet india-rubber tied securely over the end; this rubber covering can be pressed upwards by the hand on raising the lever *o e*. In the liquid is placed a little porcelain figure, to the head of which is attached a hollow glass ball *m*, which contains air and water, and has sufficient buoyancy to float the figure on the surface. In the lower part of this ball a fine hole is pierced, by which water can enter or escape according as the air in the interior is more or less compressed. The quantity of water in the glass ball is such that a very slight addition will cause the figure to sink. On raising the lever and pressing the rubber diaphragm, the air in the cylinder is compressed, and this pressure is transmitted to the water of the vessel and the air in the bulb. The consequence is that a small quantity of water penetrates into the bulb, which therefore becomes heavier and the figure sinks. When the pressure is relieved the air in the bulb expands, expels the excess of water which had entered, and the figure, being now lighter, rises once more to the surface. It is by a similar process that fish either rise or sink in water. Most fishes are furnished with an air bladder below the spine, termed the swimming bladder. The fish can compress or expand this at pleasure by means of a muscular effort, producing similar effects. As the human body is lighter, bulk for bulk, than an equal volume of water, it consequently floats on the surface, and more readily in sea water, which is denser, than fresh water. In man the head is heavier than the lower parts of the body, and consequently tends to sink. The difficulty of keeping the head above water so as to breathe freely constitutes the chief art in swimming. With quadrupeds, on the contrary, the head, being lighter than the other parts of the body, remains above water naturally, and they therefore swim intuitively.

LOGIC.—CHAPTER IV.

THE INTERPRETATION OF PROPOSITIONS, CATEGORICAL AND CONDITIONAL, HYPOTHETICAL, DISJUNCTIVE, DILEMMATIC, ETC.

EVERY proposition is a sentence, but every sentence is not a proposition. A proposition is the form of expression which an act of judgment takes when it is expressed in grammatical language with the intent of its being recognized and admitted as a logical statement. A sentence may be rhetorical rather than logical; it may be set rather before the emotions than the reason. It may, in fact, propose nothing to the judgment that it can or should accept. The statement it embodies may have no illative intent. It is not intended to be reasoned upon or from. The merely narrative statement that "Policeman B 359 was on his beat" is a proposition, in so far as it sets forth an actual fact; but it only becomes a logical proposition when it is, or is to be made, an element in a process of reasoning. An enunciative statement may, of course, be true or false, and may therefore be either affirmative or negative, and universal or particular (in different degrees); but if it is merely an enunciation, and not an enunciation to be reasoned on or from, logic has little or no interest in it. Logic takes under its charge only reasoned thought, and manipulates those propositions only which supply or are the materials of discursive thought, *i.e.* of thought progressing from experience to principle—from the seen to the scientific. That it may be made an object of intellectual acceptance, a statement must not only be set forth as a proposition, but as one that can receive substantiation, and consequently can be trusted in and accepted as truth. A logical proposition is not put before the perception only, but the understanding as well. Logic demands that each proposition should appear—or may be made legitimately to appear—in the form in which its full force may be most clearly and determinately understood. Hence the logician claims that each proposition in itself shall express, or that it may be made (as a preliminary to its being employed in reasoning) to state explicitly, all that is contained implicitly in its (intended) compass—that, in short, it shall exhibit with unmistakable clearness the precise form and matter of thought.

We know that language is only an instrument of thought. It abounds in abbreviations and ellipses, and it incorporates often emotional influences and references which are incidental or accidental. It is not quite easy to secure that it shall be an entire translucency, only conveying the exact matter of thought in the best manner. For common use, language is explicit enough if it makes a man's meaning intelligible; and therefore much elision may be allowed in it, if it serves to

facilitate the communication of thought. When, however, we require to deal scientifically with language as the representative of thought, it becomes imperative to clear it of everything which can by any possibility impede the distinct perception of the exact significancy of every proposition placed before the mind. If the statement is not definite in form and matter, if it is deficient in clearness or inappropriate in expression, logic reconstructs it, in a conscious and guarded manner, and makes it into as perfect a statement as may be, so that it is fitted for the reasoner's use. Logical precision involves formal exactness; and only when, in a consistent mental unity, an adequate and complete perception of the real intended significance of a proposition is conveyed to the understanding is a sentence such that it is logically legitimate. To secure the unvarnished, untarnished transference of thought through words conversion was elaborated, and those predeterminate methods of making our words express exact equations of our meaning, explained in the previous chapter, were arranged and prescribed.

The necessities of formal science require that we should recognize those customary forms of phrase and expression which the ordinary habits of speakers and hearers present and accept as propositions. These, of course, it requires to classify, and from these it is essential that it eliminate all that is specially predicative, in whatever form it may be presented. Before a logician can accept, reject, or classify propositions he must examine them, and see how far and under what conditions they are *predicative*, *i.e.* presented to the judgment for acceptance or rejection by the intellect in an act of reasoning. Indicative sentences are mere statements; predicative ones are statements made to the understanding for use in reasoning, either as the premises in or the conclusion of a syllogism.

Propositions which are directly and unconditionally predicative are called "categorical" (Gr. κατηγορέω, I assert or affirm positively), and these are, in the main, the form of those propositions with which logic, properly speaking, deals. In such sentences, one thing is affirmed or denied of another. These are enunciatory or declarative; they place before the mind the statement of the judgment regarding the agreement or disagreement of two concepts or terms with one another. Often, however, sentences do not appear in this simple and readily analyzable form. They may be brought before us in an interrogative style, which is intended to give them a more strongly affirmative force. For instance, the sentence "Is not man mortal? why talks he of the future?" emphatically affirms that "man is mortal," and implies that "he who is mortal cannot (or ought not to) lay confident plans for the future." Logic analyzes such sentences, brings out explicitly the implicitly twofold nature of the assertions contained in them, and places them clearly, in some distinctly defined sense, among the considerations presented to it for inquiry or thought. By the use of an imperative form of sentence we may very concisely make a statement. In the example "You have sinned: repent!" we have a series of propositions forming in reality an implied syllogism to this effect:—"All who have sinned ought to repent; *you have sinned*, therefore you should *repent*." Similarly, there is an optative form sometimes given to a sentence which is intended to emphasize an assertion. If an orator exclaims, "May the patriot's spirit descend upon us all!" he probably means to impress the hearer's mind with the idea that "the spirit of patriotism ought to glow within each human breast." An exclamation often acts as an intensitive to a sentence, as in Cassius' phrase, "Ye gods, must I endure all this!" which may be taken as equivalent to the proposition, "This experience is too much for human endurance." Thus, or in some such more or less indirect forms, sentences presented in the rhetorical style may be reduced to a somewhat equivalent logical expression. Then, and then only, so far as logic has yet proceeded in its analysis of reasoning, have propositions of this sort any proper place in the scientific consideration of thought as thought.

Language expresses thought as it *is*—sometimes carefully and completely, sometimes rash and discoloured by passion; but logic requires thought (or the expression of thought) to be arranged as it *ought* to be, as parts of a reasoning process. It examines and fixes upon the forms, types, or models of propositions which are most free from confusion, most distinct and exact, and it supplies instructions for the proper adjustment of words and meaning in such propositions as are intended to be reasoned on. Logic demands, therefore, that the expression of a thought shall be identical with the thought itself in extent and condition, in fulness and faithfulness of implication and suggestion; that there shall be no confliction of reality and expression, or of expression with expression, *i.e.* that every statement brought before the mind must be self-consistent, and that the expression shall be both efficient and sufficient in the impression it produces on the mind. Thus logic criticises language as the expression of thought, and challenges in language any faulty expression either in denotation or connotation. It insists on being provided with reasonable materials for the purposes of reasoning. In this way, there comes to be a necessity for the interpretation of propositions, so as to bring their grammatical or rhetorical forms into logical ones—such as shall be precise equivalents of what is meant. One may be told "Birds sing," and he may be unable to affirm or deny that. If he say "Yes," then his friends may inform him that the Hon. Daines Barrington states that "the greater number of birds do not sing at all;" if he say "No," they may ask him if he never heard the "music of the woods." The proposition is not in a fit condition to be reasoned on or with. It is an indefinite one. It is not true that "*all* birds sing." It is true that "*some* birds sing." But unless we can define the *some* specifically we shall not be able to reason safely on such a proposition. Some propositions, again, are trivial in themselves and not capable of being rationally used, as if one should say "A circle is a circle;" yet others having a similar form are really, by their form, made more emphatic—*e.g.* "Home is home." Some are merely declaratory or explanatory, as "This is an orange," "To pardon is to forgive." When Brabantio says, "Words are words," he means that "the comfort that is given in words is as fleeting and powerless as the air out of which they are fashioned." Even these, however, by peculiarity of pronunciation, may be made emphatic and bear a meaning of an illative character. If, for instance, one were to say, "Oranges are not worth buying unless they are really good," and a shopkeeper were to reply, "These *are* oranges," he would most probably mean, and be understood to mean, "These are really good oranges," and to imply that they are "worth buying." Similarly, a person might say, "I will not punish but pardon you—only I want to have nothing more to do with you;" and another might plead in his favour, by saying, "Oh, but to pardon is to *forgive*"—not merely to relieve from a due punishment, but to restore to former place and favour. Again, when Shakspeare says,

"Love is not love
Which alters when it alteration finds,"

he uses a phrase which logically means, "That love which alters in one person when it finds alteration in another person is not true love." Hamlet's exclamatory sentence, "Oh what a rogue and peasant slave am I!" stands, in rhetoric, as the equivalent of the logical statement, "I am, indeed, only in present spirit a rogue and a peasant slave." The interrogative phrase, "What stronger breastplate than a heart untainted?" means, "There is no breastplate stronger than a heart untainted."

When propositions are thus made expressive of distinct statements with clearly understood significations, they are suitable for logical use—*i.e.* for being made part of and taking their place in the structure of a syllogism. Logicians, it is true, have hitherto, in their treatises, given little help towards the reduction of such grammatical or rhetorical sentences into the forms of logical propositions. Indeed, it is scarcely possible to produce rules that will guide mechanically to the accomplishment of such a process. The use of language to express thought is complicated by its use to indicate feeling and all the subtler degrees of emotion, of which logic regards itself as free to take no real cognizance. In the last verse, for instance, of "The Deathbed," by Thomas Hood, a fine illustration occurs of the beauty and tenderness that can be incorporated in an indicative sentence, and of the exquisite

refinement of feeling, of which logic takes for its purposes no special notice.

> "For when the morn came dim and sad,
> And chill with early showers,
> Her quiet eyelids closed—*she had*
> *Another morn than ours*."

The logical statement—apart from its deep pathos, its touching faith, its plaintive patience—is simply, "she is dead," and that is the categorical equivalent or the logical significancy of the phrase.

Every sentence employed in reasoning must either be indicative or be convertible into, and able to be understood as, a logical proposition. Each must also either be actually quantified or capable of being readily quantified in thought. The sentence, for instance, "There can be but few who deny the doctrines of political economy," is probably intended to mean, "Almost everybody accepts the doctrines of political economy," and is therefore a particular affirmative [I]. "Does anyone dare despise the law!" would bear the signification logically, "No one dares to despise the law" [E] or "All (who are referred to in the proposition) are law-abiding" [A]. In the one case it is a universal negative, and in the other it is converted into a universal negative.

All the propositions to which the student's attention has been as yet directed, are or may be [made] *categorical*. Logicians, however, find themselves under the necessity of acknowledging and dealing with some propositions which do not make affirmations or negations simply stated and unconditional. An element of uncertainty enters into many experiences, and that must be allowed for. Some relations of things are quite certain if the preliminary conditions are secured, and of some we know that if one element prevails, a certain (foreseen) result will follow, but that if a different element prevails, a different but equally foreseen result will occur. This distinction in the nature of experiences has led logicians to adopt a subdivision of propositions designated *conditional*, and this is again subdivided into propositions that are (1) *hypothetical*, (2) *disjunctive*, or (3) *dilemmatic*.

Conditional propositions are, of course, those in which the statement of the relation between the subject and the predicate is not set forth as a simple and direct one, but as dependent on something else for its precise determination; *e.g.* "If Horace Walpole is right, Richard III. was not a monster." This condition of determinative affirmation may be, as regards this special relation, inherent (1) in the subject, (2) in the predicate, or (3) in both. In the first case, the things thought of are stated to hold such a relation to one another that the former can only be thought of when we think of the other—they hold to each other the relation of antecedence and consequence; *e.g.* "If this severe weather lasts, many people must be ill off," *i.e.* "This severe weather —if it continues—must be followed by much suffering." We see at once that the condition attaches to the antecedent, and that only on the supposition stated being fulfilled, the consequent is necessarily to be looked for. In the second kind of proposition, the relation of the subject is not in reality distinctly asserted in regard to one single predicate, but to a special plurality of attributes which, though not all capable of being predicated of it conjointly, must, as to some one or other of them, be considered as attached to the subject; *e.g.* "The universe is either (1) eternal in itself, (2) the result of chance, or (3) the product of an intelligent creator." The third class of propositions now under consideration have conditions attached to both subject and predicate; *e.g.* "If our actions are right, they must conform either to the laws of nature or the laws of the state.

It will be seen, by reflecting on these and similar propositions, that it is only in so far as they are really categorical (*i.e.*, regarded as distinctly and distinctively affirmative) that they are appreciable by logic. "Cæsar is a man," "Cæsar is mortal," are both categorical propositions; but "If Cæsar is a man he is mortal" is conditional. It is plain that this sentence suggests that the true coincidence of "Cæsar" and "mortality" depends on the truth—however it is to be discovered—of Cæsar's being "a man." "If Cæsar is a man he is mortal;" "If Cæsar is not a man he is not mortal." Either "Cæsar is a man and mortal," or "Cæsar is not a man and not mortal." If Cæsar is the one he is also the other, and *vice versa*. It might, perhaps, appear more distinctly categorical if it were put thus:—"That Cæsar is mortal is a legitimate inference from the fact that he is a man;" "The fact being that Cæsar is a man, it is also the fact that he is mortal." Thus the statement is brought into such a form as gives it that unity of thought (as regards the relation of subject and predicate) which constitutes a logical proposition. We can regard the one as distinctly predicated of the other. As it is of great importance to habituate the mind to the perception of the real signification of propositions before bringing them together in their syllogistic relations, we shall notice a few examples of other forms of expression which require reduction to proper propositional equivalence in order that their exact signification, as it is to be dealt with in reasoning, may be known. "Virtue alone is true nobility" (Juvenal, viii., 20) may mean "Virtue is the only true nobility," or "Nothing else than virtue is noble." In the famous phrase of Pilate, "What I have written, I have written," we have a sentence which may signify, "What I have written is correct —as it is my wont to write," "By what I have written I abide," "What I have written shall stand unaltered." The Stoical egotistic phrase, "Except the wise, all men are fools," was really meant to signify "All men are fools, except the Stoics (who alone are the wise)." "The greatest of all losses is the loss of character," indicates (1) that the loss of character is a great one, and also (2) that the loss of the moral purity which causes the loss of character is the greatest loss that can befall a man. If we take the statement, "Either vice is hateful or religion is false," we have two alternatives, of which as yet nothing has appeared to demand from us the assertion of one as excluded from, inconsistent with, or in logical contradiction to the other. Vice may be hateful; religion may be false. To many vice is not hateful; some religions must be false. But this proposition asks us to assent to one or other of the following statements:—(1) Vice is hateful, and religion is not false. (2) It would be an argument against the truth of religion if vice were found to be otherwise than hateful. Moral philosophy must teach us whether *all* vice is hateful, and what makes it so; while theology must inform us on what grounds religion may be known to be false, and enable us to quantify our assertion into such forms as these:—"All vice is hateful," "No vice is hateful," "Some vice is hateful," "Some vice is not hateful;" and "All religion is false," "No religion is false," "Some religion is false," "Some religion is not false," as the case may be. Meanwhile the sentence as it stands seems to bear the interpretation, "It is a fact that vice is hateful, and religion shows it should be so;" and "Were it not a fact that vice is hateful religion would have taught us falsely."

EXERCISES.

1. In the following lines from "The Golden City," by Frederick Tennyson, which one is logically equivalent to "To-morrow they were all safe from the peril of their position?"

> "All day they rocked upon the stormy deep,
> Till night beset them: and they could not tell
> The signal lights—and they began to weep;
> And the dark waters smote them and they fell.
> But oh! they woke in wonder!"

2. What is the logical significance of this sentence?

> "There is surely a piece of divinity in us—something that was before the elements, and owes no homage to the sun."

3. How might we rhetorically express these statements?

> Man is certainly an immortal being.
> He is not wholly of the earth, earthy.

4. What is the difference in *meaning* between the expressions which follow?

> Nature has implanted in the inmost heart an instinctive abhorrence of sin.

> "O surer than suspicion's hundred eyes
> Is that fine sense, which to the pure in heart
> Reveals the approach of evil."

5. Determine the character of the following propositions:—

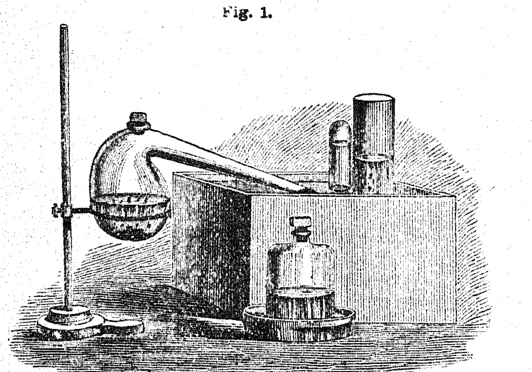
Man is reasonable. All Frenchmen are Europeans. Impure iron is brittle. A miser never refuses money. Socrates was wise, but not learned. Cromwell was either republican or rebel. Washington was neither knave nor fool. No man can serve two masters. A part is less than the whole. Every man is guilty of many faults.

CHEMISTRY.—CHAPTER VI.

CHEMISTRY OF ELEMENTARY BODIES—OXYGEN—HYDROGEN—NITROGEN—COMPOSITION OF THE ATMOSPHERE—COMPOUNDS OF NITROGEN AND OXYGEN—COMPOUNDS OF NITROGEN AND HYDROGEN—AMMONIA.

OXYGEN (symbol, O; atomic weight, 15·96; density, 15·96.).—Oxygen was discovered in 1774 by Priestley in England, and about a year later by Scheele in Sweden, and described as *dephlogisticated air*. The name oxygen was given to it by Lavoisier (from *oxus*, acid; and *gennao*, I give rise to). It is a colourless invisible gas, possessing neither taste nor smell.

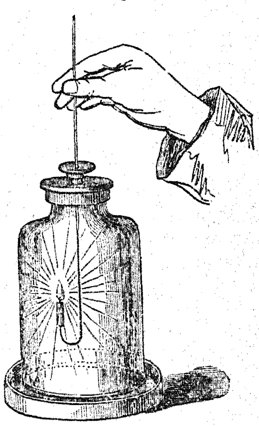
Fig. 1.



It exists in a free state in the atmosphere, of which it constitutes about one-fifth by volume. It forms nearly one-half the weight of the earth's crust, and eight-ninths by weight of water. Oxygen gas can be obtained from the air, but it is more readily prepared from many compounds which contain it in large quantities. Oxygen may be readily obtained by heating potassium chlorate (chlorate of potash), $KClO_3$, which yields 39·2 per cent. of its weight of this gas. In order to collect the oxygen the chlorate of potash, powdered, is placed in a small, thin glass flask, or a retort, which is a glass vessel ending in a long tubular neck. The lower end of this tube dips under the surface of water in a pneumatic trough, and the gas, as evolved from the end of the tube when the flask is heated, is collected in a jar or bottle filled with water, and placed with its mouth downwards over the tube, as shown in fig. 1. It is, of course, necessary that the mouth of the jar should be *under* the surface of the water in the trough, that the water in it may be supported by atmospheric pressure. After it has been nearly filled with gas it may be removed from the trough by slipping under it a saucer or tray, as shown in cut, which will hold sufficient water to keep the mouth closed.

All the elements, with the single exception of fluorine, combine with oxygen to form *oxides*. In this act of combination, which is called *oxidation*, heat is always evolved, and frequently light also is emitted, as in the process of *combustion*. All bodies which burn in air burn with increased brilliancy in oxygen gas. Thus, if a lighted taper attached to a bent wire be blown out, and while the wick remains red hot, dipped into a jar of oxygen, as in fig. 2, it instantly rekindles with a slight explosion, and burns with greatly increased brilliancy. A spark in charcoal may be fanned into a blaze by a stream of oxygen (fig. 3). A small piece of phosphorus, when inflamed, burns in oxygen with a most intense light, as shown in fig. 4, in which the phosphorus is introduced in a spoon into a jar of oxygen. Even iron or steel wire may be burned in this gas. A coil of fine wire (fig. 5) has attached to its end a piece of wick dipped in melted sulphur. This is lighted and the whole introduced into the oxygen. The wire is kindled by the sulphur and burns with an intense white light, and with brilliant scintillations, the globules of fused oxide of iron which fall being at so high a temperature as to fuse themselves into the glass.

Fig. 2.



Ordinary combustion consists in the union of oxygen with other bodies, and is the great source of artificial light and heat. When a body combines with oxygen it is said to be *burned*, but it does not, of course, cease to exist. A new

Fig. 3.

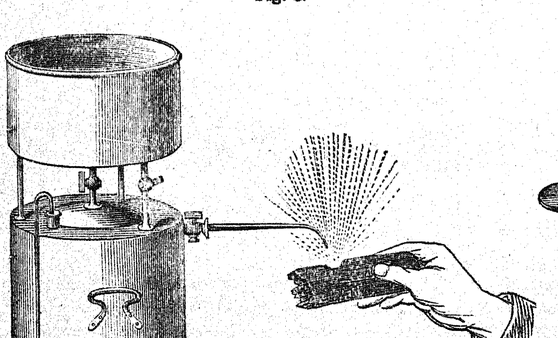


Fig. 4.

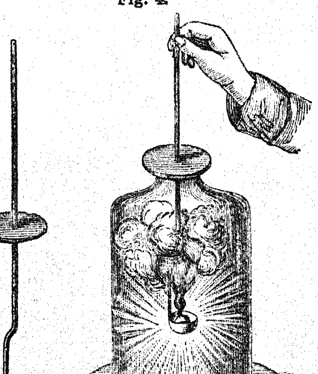
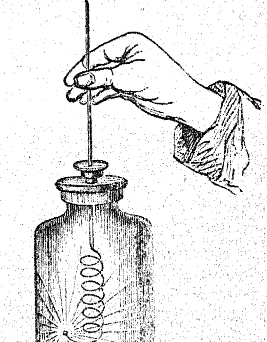


Fig. 5.



substance is formed, which may be either solid, liquid, or gaseous. When iron is burned, a solid (oxide of iron) is produced, exactly equalling the weight of iron and oxygen which have disappeared in the operation. By suitable means both may be recovered from the product.

To produce an intense heat means are contrived to force large quantities of air (one-fifth of which is oxygen) through the furnace or flame employed, as in the case of the blowpipe and the blast furnace. In the processes of nature oxygen is set free by the action of the solar rays upon the carbonic acid gas (carbonic dioxide) contained in the air; this is carried out through the intervention of the green colouring matter of plants, trees, and vegetables. Sunlight has the power, in presence of this green colouring matter, of decomposing car-

bonic acid; the carbon is absorbed by the plant for its growth, whilst the oxygen is set free, and is used for the support of animal life in the process of respiration. In the act of inspiration animals breathe in the oxygen of the air; in the act of expiration the carbonic acid gas is expelled. It is the oxidation of the constituents of the body by the act of breathing that maintains the temperature of the animal system; in fact the blood contains substances which slowly burn by the aid of oxygen thus introduced into the system. When this chemical process stops the animal dies. Carbonic acid, nitrogen, and some other gases cause death when inhaled, as they do not contain any free oxygen, and the process of oxidation in the body ceases.

Oxygen is, bulk for bulk, slightly heavier than atmospheric air, its specific gravity being 1·10563, air being unity. Oxygen gas was liquefied by Pictet in 1877 by a pressure of about 300 atmospheres, and at a temperature of $-140°$ C. This extreme pressure (4500 lbs. per square inch) has since been shown to be unnecessary. A pressure of sixty atmospheres (900 lbs. per inch) is sufficient, if combined with a temperature of $-150°$ C. (produced by the evaporation of liquid ethylene). At this temperature and pressure nitrogen can also be liquified, and as atmospheric air is a mechanical mixture of one volume of oxygen with four of nitrogen it is also liquefied in the same way. The specific gravity of liquid oxygen is the same as water. Oxygen can be respired, and supports life four or five times longer than an equal quantity of air. Nevertheless an animal which breathes pure oxygen for any length of time suffers from great excitement, followed by debility and death. Phosphorus and many metallic compounds absorb oxygen from the air at ordinary temperatures. Iron, zinc, lead, and some other metals are unaffected by dry oxygen, but if moisture is present they are covered with a layer of oxide: iron rust is so produced. Pure oxygen undergoes a remarkable modification when a succession of electric sparks is passed through the gas; it then attains more active properties, and emits a peculiar and somewhat metallic odour, and is able to set free iodine (I) from potassium iodide (KI), as well as to effect oxidations which common oxygen does not possess the power of doing. This *allotropic* modification of oxygen is termed *ozone*. It is oxygen in a condensed state, and is $1\frac{1}{2}$ times as heavy as oxygen; that is, 3 volumes of oxygen condense to form 2 volumes of ozone. Ozone has been obtained in the liquefied state. It exists in the atmosphere, and air charged with it exerts an irritating action on the lungs. Ozone is decomposed by heat, gradually at 37·7° C., instantly at 143·3° C. It is an extremely powerful oxidizing agent, possesses strong bleaching and disinfecting powers, and corrodes cork, caoutchouc, and other organic substances.

Hydrogen (symbol, H; atomic weight, 1; density, 1).—Hydrogen is a colourless invisible gas, tasteless, and inodorous when quite pure. It is the lightest body known, being 14·47 times lighter than air, and modifies any sound emitted in it by giving it a higher pitch than in air, as is shown by ringing a bell in a jar filled with hydrogen (fig. 6). It is inflammable, and burns, when ignited, with a pale yellowish

Fig. 6.

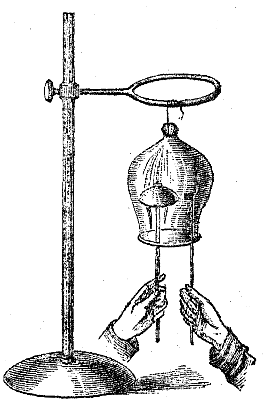
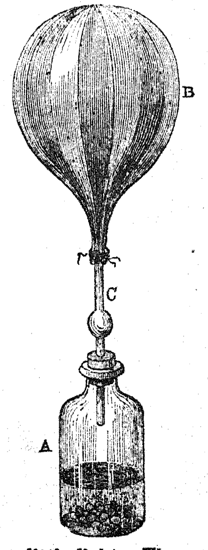


Fig. 7.



flame, evolving great heat, but very little light. The product of the combustion is water. Hydrogen is incapable of sustaining animal life. Water consists of hydrogen in the proportion of one-ninth part of its weight. Hydrogen was at one time used for filling air-balloons, being made on the spot from zinc or iron and dilute sulphuric acid, as shown in fig. 7, where A is a flask containing scrap zinc and dilute sulphuric acid, and C a pipe by which the gas is introduced into the miniature balloon B, which, in consequence of the low specific gravity of this gas, is able, when inflated, to float in air as a cork does in water—that is, by displacing a volume of air which exceeds its own weight. Coal gas is now employed, which, although inferior to hydrogen in buoyant power, is found in practice to possess certain advantages, and its greater density is compensated by increasing the volume of the balloon. Hydrogen may be obtained by the action of red-hot iron on water. A wrought-iron pipe like a gun-barrel, A, fig. 8, filled with iron filings, is heated in a furnace, F, and steam from a flask or boiler, B, is passed over the red-hot filings through the tube. Hydrogen is driven off, and by means of the tube C conducted to a receiver in the pneumatic trough, and oxide of iron is left in the tube. Hydrogen, and all the other gases, can be liquefied by the application of great cold and great pressure. Caillelet, and also Pictet, have liquefied the gas at a temperature below $-200°$ C. In the solid state it appears as a jet of steel-blue coloured particles, indicating its probable metallic nature.

Fig. 8.

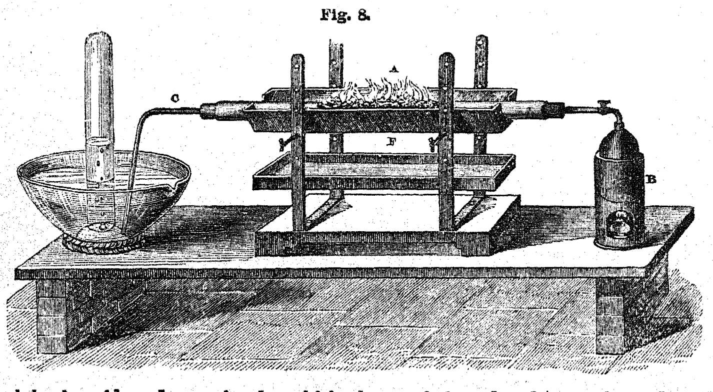
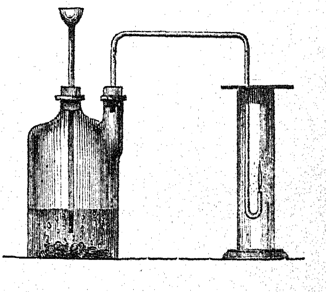


Fig. 9.

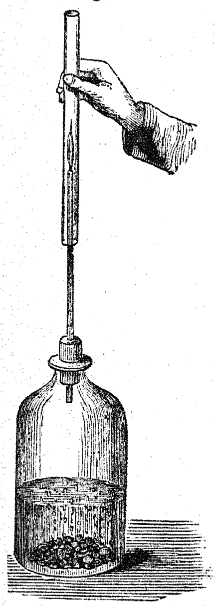


The oxides of hydrogen are *water* or *hydrogen monoxide* (symbol H_2O; combining weight, 17·96; density, 8·98) and *hydrogen dioxide* (symbol, H_2O_2; combining weight, 33·92). Water is readily decomposed into the two elementary gases, oxygen and hydrogen, by the passage of a voltaic current through it, and it can be easily shown that water is the product of the combustion of hydrogen. Let the flask, shown in fig. 9, contain fragments of zinc or iron. A mixture of water

and sulphuric acid is introduced through the vertical tube, the lower end of which must be covered by the liquid. Bubbles of hydrogen are given off, and after sufficient time has elapsed to permit all the air to be driven from the flask (otherwise an explosion might ensue) the stream of gas can be ignited as it issues from the bent tube. If the flame be now introduced into a large covered glass jar, the interior will be speedily covered with condensed water, and this condensation will continue so long as the jar is kept sufficiently cool. This condensation may also be seen by holding a cold metal plate over a gas flame, as illuminating gas consists mainly of hydrogen.

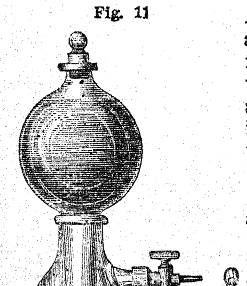
If an electric spark be passed through a mixture of two volumes of hydrogen with one of oxygen, the gases unite with explosive violence. In spite of the momentary expansion of the gases, due to the great heat evolved in combining, it is found that the product—water, vapour, or steam—only amounts to *two volumes* in place of three. These explosions may be so combined as to produce a musical note. The "singing-flame" (fig. 10) is a small jet of lighted hydrogen, over which a glass tube, half an inch or more in diameter, and one or two feet long, is held. If this funnel be properly managed a succession of small explosions will result in a clear musical note.

Fig. 10.



A mixture of oxygen and hydrogen may be preserved for any length of time without undergoing change. But combination is instantly brought about by flame, by the electric spark, or even by introducing a red-hot glass rod. If the mixed gases be heated in a vessel containing pulverized glass, or any sharp powder, they begin to unite in a gradual manner without explosion. The presence of metals disposes them to unite at a still lower temperature, and newly prepared spongy platinum has so powerful an effect that it quickly becomes red hot, and then inflames or explodes the mixture—a property which has been utilized in the hydrogen fire apparatus to inflame a jet of the gas directed on a piece of spongy platinum (fig. 11). Water exists in nature in three forms. At all temperatures between 0° and 100° C. it takes the liquid form; above 100° C. it assumes the gaseous form at ordinary atmospheric pressure. The melting point of ice is always a constant temperature, the 0° C. In passing from the solid to the liquid state water becomes reduced in volume, and on freezing, a sudden expansion of volume, from 1 to 1·09, takes place, which exerts an almost irresistible force. In this passage from the solid ice to liquid water not only is there the alteration in volume, but also a remarkable absorption or disappearance of heat occurs (see NATURAL PHILOSOPHY). In the passing from the liquid to the gaseous state water also exhibits several important phenomena, and in this passage from the liquid to the gaseous state a large amount of heat also becomes latent. Pure water and ice, when seen in large masses, possess a blue colour. To obtain pure water, river or spring water is *distilled;* that is, the water is boiled, and the steam evolved condensed to collect the *distilled water*. Ordinary water contains more or less solid matter in solution, derived from the surface of the earth over which the water flows; this dissolved solid matter is left behind on boiling off the water into steam. Rain water is the purest form of water occurring in nature, but contains impurities, from the dust, &c., in the air. All fresh water on the earth's surface has been derived by a vast process of evaporation from the ocean, having been deposited in the form of rain or snow from the atmosphere. All the rain-water eventually passes into the ocean by springs and rivers, carrying with it the soluble constituents dissolved out of the earth's strata through which it has percolated. This continual accession of soluble salts, and removal of pure water by evaporation, maintains the saline property of sea-water, which contains about thirty-five parts of solid matter, twenty-eight of which are common salt (NaCl), in solution in 1000 parts of water. The presence of oxygen derived from the air dissolved in the water of lakes, rivers, and seas, enables fish to maintain their respiration; as the water passes through their gills the oxygen is absorbed to purify their blood. The solvent properties of water far exceed those of any other liquid known. Water dissolves very unequal quantities of the different gases, and very unequal quantities of the same gas at different temperatures. Thus—

Fig. 11



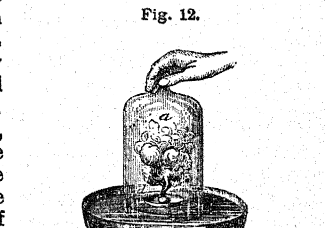
ONE VOLUME OF WATER UNDER ORDINARY ATMOSPHERIC PRESSURE (760 MM.) DISSOLVES,

Temperature.	Oxygen.	Nitrogen.	Hydrogen.	Nitrogen Monoxide	Carbon Dioxide.	Chlorine.	Hydrochloric Acid.	Ammonia.
0°C.	0·041	0·020	0·019	1·31	1·80	—	505	1180
10°	0·033	0·016	0·019	0·92	1·18	2·59	472	898
20°	00·28	0·014	0·019	0·67	0·90	2·16	441	680

Hydrogen dioxide (H_2O_2) contains twice as much oxygen as water. It does not occur in nature, but may be artificially prepared by passing carbonic acid gas through barium dioxide suspended in water, when barium carbonate separates out as a white powder insoluble in water, and hydrogen dioxide remains in solution. In consequence of the readiness with which it gives off oxygen, hydrogen dioxide acts as a powerful bleaching agent, rapidly oxidizing and destroying vegetable colouring matter.

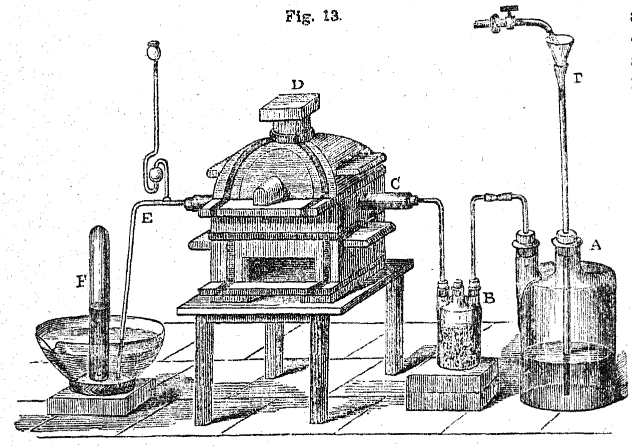
Nitrogen (symbol, N; atomic weight, 14·01; density, 14·01).—Nitrogen exists in the free state in the atmosphere, of which it constitutes four-fifths by bulk. It occurs combined in the bodies of plants and animals, and in various chemical compounds, such as *nitre*. It may be obtained in several ways—one of the simplest being to burn out the oxygen from a confined portion of air by phosphorus, which should be laid in a cup, *d* (fig. 12), floating in water, and after it is ignited the bell-glass, *a*, should be inverted over it. White fumes of a compound of phosphorus and oxygen, termed phosphorous pentoxide, at first fill the vessel, but these are shortly dissolved in the water, leaving the nitrogen in a nearly pure state. Nitrogen may also be prepared by passing air over red-hot metallic copper, as in the apparatus shown in fig. 13, where A is a large flask, from which the air is expelled by pouring in water through the tube T. The air is dried in the flask B by passing over fragments of pumice impregnated with sulphuric acid. The tube C contains the metallic copper (reduced from the black oxide of copper by hydrogen), kept red-hot by the furnace D, which combines with the oxygen, forming solid copper oxide, and leaving the gaseous nitrogen

Fig. 12.



in a pure state. E is a tube leading to the receiver F in the pneumatic trough. Nitrogen is a colourless, tasteless, inodorous gas, slightly lighter than air. Its specific gravity is 0·972, air being 1·0. At a very low temperature and under a high pressure nitrogen condenses into a colourless liquid. Nitrogen does not readily combine with

Fig. 13.



other substances—neither supporting combustion nor animal life, nor burning itself. When made to combine with hydrogen it forms *ammonia* (NH_3), and when united with both oxygen and hydrogen it forms a strong acid, nitric acid ($H_2ON_2O_5$).

The exact composition of atmospheric air (see NATURAL PHILOSOPHY) has been very accurately determined. Besides nitrogen and oxygen, the air contains traces of carbon dioxide, and a very variable proportion of aqueous vapour, a trace of ammonia, and a little carburetted hydrogen. The oxygen and nitrogen are in a state of mixture, not of combination, and their ratio is always uniform, the diffusive energy of the gases being sufficient to maintain this perfect uniformity of mixture. The carbon dioxide, being influenced by local causes, varies considerably.

COMPOSITION OF THE ATMOSPHERE.

Nitrogen,	by weight	77 parts,	by measure	79·19
Oxygen,	"	23 "	"	20·81
		100 "		100·00

Carbon dioxide, from 3·7 measures to 6·2 measures in 10·000 measures of air. Aqueous vapour variable, depending greatly upon temperature. Ammonia, a trace—about 1 part in 1,000,000 of air. Although this amount is excessively small, it nevertheless plays a very important part, as it is mainly from the presence of this ammonia that vegetables obtain the nitrogen they require to form their seeds and fruit. Plants do not appear to have the power of assimilating the free nitrogen of the atmosphere. The amount of volatile organic matter suspended in the air greatly influences the healthiness of the special situation. A crowded room is full of organic putrescent substances, and the unhealthiness of marshes and other districts doubtless arises from the presence of some organic impurity. *Ozone* is always present in fresh air.

There are five distinct compounds of nitrogen and oxygen.

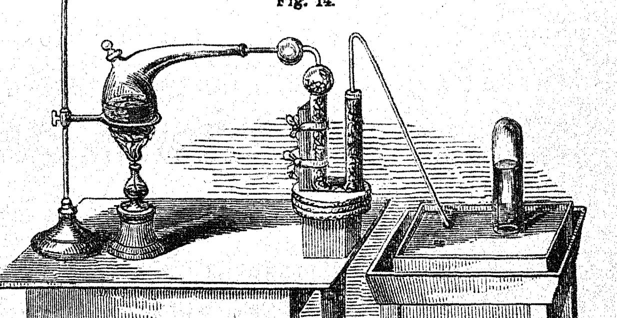
	By Weight. Nitr.	Oxy.		By Volume. Nitr.	Oxy.
Nitrogen monoxide, N_2O, . . .	28	16	...	2	1
Nitrogen dioxide, N_2O_2 or NO,	28	32	...	2	2
Nitrogen trioxide, N_2O_3, . . .	28	48	...	2	3
Nitrogen tetroxide, N_2O_4 or NO_2,	28	64	...	2	4
Nitrogen pentoxide, N_2O_5, . . .	28	80	...	2	5

The oxygen contained in these compounds is therefore in the proportion of the numbers 1, 2, 3, 4, 5, to one and the same quantity of nitrogen. The *law of chemical combination in multiple proportion* is here clearly exemplified, and no compounds exist containing intermediate quantities of oxygen. This law has already been explained on the principle of the *atomic theory*. In these compounds of nitrogen and oxygen the lowest consists of two atoms of nitrogen with one atom of oxygen. The next compound that can be formed must therefore be produced by the addition of another atom of oxygen, which is N_2O_2, or nitrogen dioxide. The next will be by the addition of another atom of oxygen, and so on. Thus, as an atom is indivisible, no intermediate compound can be formed. The law of multiple proportions is based upon experimental results, and therefore stands unchangeable in the science of chemistry. The atomic theory, which is now used to explain this law, may perhaps hereafter give place to some other theory more perfectly suited to the explanations of new facts which chemical research reveals from day to day. There are already certain notable exceptions to this law, which occur in the case of phosphorus and arsenic, whose vapours possess a density twice as great as that required to be in accordance with the above law, and the same with zinc and mercury, whose density is only half their atomic weight.

Nitrogen monoxide or *nitrous oxide* (N_2O; atomic weight, 43·98; density, 21·99) is obtained by heating ammonium nitrate in a flask, and collecting the gas over warm water. Nitrous oxide is a colourless and inodorous gas; when inhaled it produces a peculiar intoxicating and anæsthetic effect, and from this cause has been termed *laughing gas*. If quite pure, or mixed with atmospheric air, it may be breathed for a short time without danger. The effect is very transient, and is not followed by depression. The gas is frequently used as an anæsthetic in dental surgery.

Ammonia (NH_3; atomic weight, 17·01; density, 8·5).—Nitrogen and hydrogen form only this single compound *ammonia*. It is chiefly obtained from the decomposition of animal or vegetable matter containing nitrogen and hydrogen, and is quickly formed under the influence of temperature; thus when horns, or clippings of hides, or coal are heated, ammonia is evolved; from this reason it is sometimes called *spirits of hartshorn*. Guano, the dried excrement of sea-birds, and the urine of animals contain large quantities of ammonia. Ammonia is now chiefly obtained from the ammoniacal liquors of the gas-works. Hydrochloric acid is added to this liquor, and the solution evaporated, when the sal-ammoniac of commerce is obtained. Ammoniacal gas is colourless, and possesses a most pungent and peculiar smell, well known as that of smelling salts. It is pre-

Fig. 14.



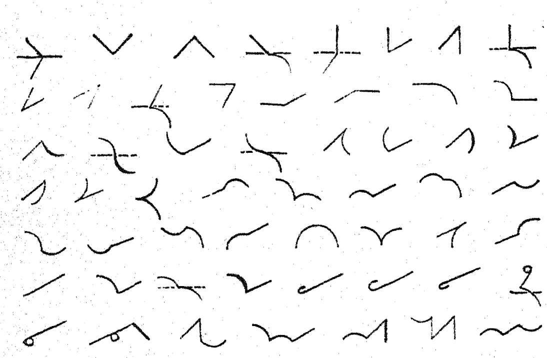
pared by mixing sal-ammoniac (ammonium chloride) with an equal weight of slaked lime, and subjecting the mixture to heat in a glass retort, when ammoniacal gas is given off, and

may be received in a flask filled with mercury, as water rapidly dissolves this gas. The apparatus employed is shown in fig. 14. It is lighter than air, its specific gravity being 0·59. Both the gas and the aqueous solution possess a strong alkaline reaction, turning red vegetable colours blue. It unites with the most powerful acids, forming compounds termed the salts of ammonia. Ammonia condenses to a colourless liquid at a pressure of seven atmospheres at a temperature of 15° C., and freezes at a temperature of −75° C. into a transparent solid. The principle of the latent heat of vapours has been employed in the case of ammonia in Carré's freezing machine. (See NATURAL PHILOSOPHY.)

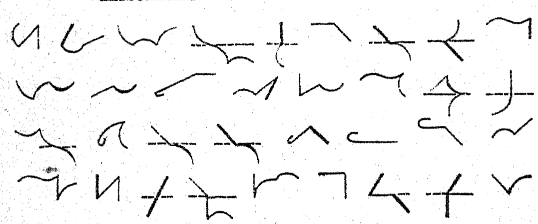
SHORTHAND.—CHAPTER III.

THE following exercise on the r and / combinations, and the miscellaneous combinations, should be carefully copied until accuracy and facility have been attained:—

R AND CH COMBINATIONS.

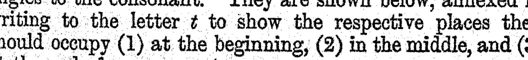


MISCELLANEOUS COMBINATIONS.



LONG VOWELS.

There are six simple long vowels in the English language—viz., ah, a, ee, au, o, oo, as in *alms, ale, eel, awl, ope, food.* The first three are represented in phonography by a *dot,* and the last three by a short stroke or *dash,* written at right angles to the consonant. They are shown below, annexed in writing to the letter *t* to show the respective places they should occupy (1) at the beginning, (2) in the middle, and (3) at the end of a consonant.



All these vowels should be pronounced as simple, single sounds, giving to them the name-sounds indicated in the examples given above.

METHOD OF PLACING THE VOWELS.

When a vowel is placed on the left-hand side of a perpendicular or sloping consonant-sign, it is read before the consonant; and when put on the right-hand side it is read after the consonant. A vowel placed above a horizontal letter-sign is read before the consonant, and when written below, it is read after the consonant.

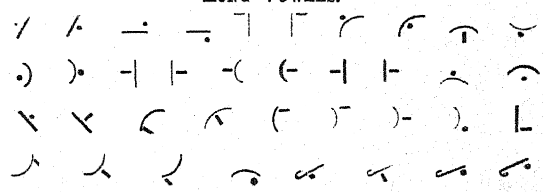
The vowels are written, as has been said, in three places—at the beginning, in the middle, and at the end of the consonant. The beginning of the consonant, whether written upward or downward, is, of course, the proper place of the first vowel-sign, and the other places are calculated from this position. The letter *l,* for instance, when written upward, has the vowel places reckoned from the bottom upward, thus ; but when, as must frequently happen, it is joined to another consonant, and written downward, the proper positions of its vowel are reckoned downward, in this way, .

We may note now, for the student's guidance, that vowels placed at the beginning of a consonant are called first-place vowels; vowels written in the middle, second-place vowels; and those at the end, third-place vowels.

The vowel points, or dots and strokes or dashes, ought to be written at a little distance from the consonants.

The pupil having fixed in his mind the foregoing instructions, should now diligently study, and carefully copy, the following exercises on the foregoing long vowels:—

LONG VOWELS.



Exercise.—Write each word first in shorthand, then in longhand—performing the exercise (1) in perpendicular columns, and (2) in horizontal lines.

Baa, pa, ma, tah (a child's "thank you"), Shah.
Aid, day, eight, Tay, Bey, ache, yea, they, gay, fay.
Bee, knee, thee, eve, fee, eel, lea, each, she, pea, ease.
Awl, gnaw, daw, jaw, maw, caw, paw, haw.
Go, oak, beau, Joe, foe, ope, know, Co. (Company).
Loo, too, woo, coo, pooh!

SHORT VOWELS.

Besides the six long vowels already explained, there are in the English language these corresponding six short vowel-sounds, as they are heard in the simple and well-known words *pat, pet, pit, knot, nut, foot.* These short vowels, as they are called, are represented by dots and strokes written in the same relative positions or places as the long ones; but they are made lighter, so that they may in this way indicate the briefer character of their vocal duration. They are exemplified hereunder, as in the case of the long vowels, written alongside of *t,* and have in these instances the sounds found respectively in the words *am, pet, ill, on, up, foot:*—

It is somewhat difficult to give these vowel-sounds alone, and the pupil will find it convenient, and it will, we think, help him, if he sounds them before *t;* thus, *at, et, it, ot, ut, oot.* As a good many learners of phonography have experienced great difficulty in catching with precision the true sounds of these short vowels, it will be well for the pupil to carefully note the proper sounds, and to keep them constantly on his tongue-tip as he proceeds to write out the exercises on the vowels, after having carefully read the next paragraph on the "method of placing the vowels," and the "method of placing a vowel between two consonants."

We have already referred the vowels to their positions, and have said that they are called, according to the positions they thus take, vowels of the first place, second place, and third place respectively. The first-place vowels are *ah,* as in *father; ă,* as in *at; au,* as in *awl; ŏ,* as in *on.* The second-place vowels are *ā,* as in *ape; ō,* as in *oak; ĕ,* as in *pet; ŭ,* as in *up.* The third-place vowels are *ee,* as in *feet; oo,* as in *poor; ĭ,* as in *is; oo*, as in *food,* and may be exhibited tabularly thus:—

1.	āh	ă	aw	ŏ
2.	ā	ō	ĕ	ŭ
3.	ee	oo	ĭ	oo

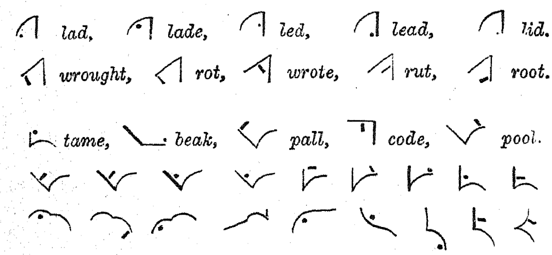
When a vowel comes between two consonants, however, it is possible to write it either (1) after the first, or (2) before the second, as take, or take. To secure uniformity, the following rules are observed:—

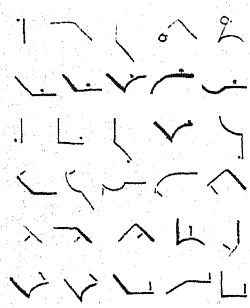
First-place vowels are written after the first consonant, as talk, not talk.

Second-place vowels are written after the first consonant when they are long, as dome, and before the second when they are short, as dumb.

Third-place vowels, whether long or short, are written before the second consonant, as team, not team; teach, not teach.

The following exercises should now be written out, paying special attention to the method of writing the respective vowels in their proper positions, as shown in the foregoing rules:—





Back, bag, batch, sham, pang, lack, tack, match, map, nap.

Check, deck, etch, gem, jet, fed, bet, web, ledge, red, debt.

Pip, bib, mill, live, kick, kid, jig, nib, fib, lip, chip, fig, big.

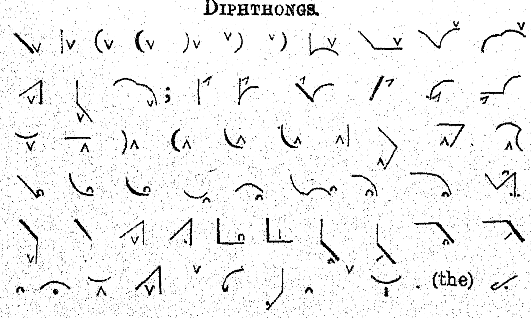
Long, dock, dog, Tom, fog, chop, pod, nod, got, lodge.

Cup, chub, chum, muff, love, tuck, dug, gum, mum, touch.

Push (down. *sh*), bush, cook, look, shook, hook (down. *h*).

The double vowels heard in the words ice, owl, due, boy, are represented by small angular marks thus, i ᵛ, as in *ice;* ow ˄, as in *owl;* u, as in *due;* oi, as in *boy.* The signs for i (ᵛ), ow (˄), are written by themselves for the word *I, how*—"I" being above the line, and "how" on it. When either of these diphthongs commences a word, the first place is the most convenient, as eyes, ounce; in other cases they are generally more easily written in the third place, as time, thou. The pupil should write out the exercise given below, placing the words represented by the phonographic signs after each of the words in their order, properly spelled. The lines may be written out (1) in columns, having the phonographic representation followed by the word meant, in ordinary longhand; (2) in lines with the words underneath; and (3) in any other arrangement which may strike the fancy.

DIPHTHONGS.



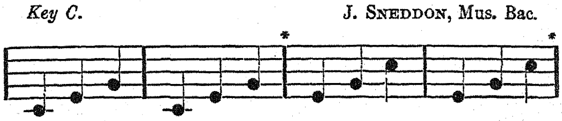
MUSIC.—CHAPTER III.

SECTION II.—IMPORTANCE OF SPECIAL EXERCISES FOR THE VOICE—EXAMPLES, COMMON, TRIPLE, AND COMPOUND COMMON TIME—ILLUSTRATIVE PIECES—QUARTER PULSES—TIME RELATION EXEMPLIFIED.

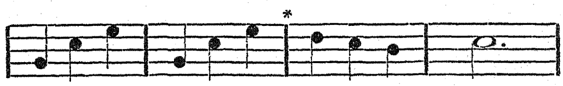
WE begin the second section of this chapter with a few exercises built on the two chords, tonic and dominant, to the study of which attention has previously been directed. In a letter to one of her royal patrons the celebrated songstress, Adelina Patti, is reported to have said—"At the age of fourteen years my voice, from over-exertion, began to tremble, and I would have lost it altogether if, as had been proposed, I had been sent to Italy. For two whole years Strakosch, my tutor, who had married my sister Amelia, forbade me to sing a note in public. After that time, when, by judicious chord and scale practisings, he had rendered my voice stronger, purer, and more flexible than ever, I was allowed to appear in the New York Academy of Music, and success was assured." Similar experiences might be related of nearly every great artist. The importance of exercises for the voice, properly written and painstakingly executed, cannot well be over-estimated, and has been recognized and acted upon ever since the infancy of the vocal art. If sung softly and regularly, with attention to the directions already given, the student will find the next three exercises very helpful in tuning the voice and improving the quality of its tone.

Exercise 48.—DOH ON FIRST LEDGER LINE BELOW.

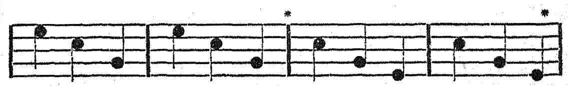
Key C. J. SNEDDON, Mus. Bac.



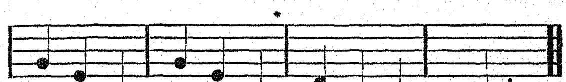
| d : m : s | d : m : s | m : s : d' | m : s : d' |
La - - - | - - - - | La - - - | - - - -
Lay - - | - - - - | Lay - - - | - - - -
Lo - - | - - - - | Lo - - - | - - - -
Lee - - | - - - - | Lee - - - | - - - -



| s : d' : m' | s : d' : m' | r' : d' : t | d' : — : — |
La - - - | - - - - | La - - - | - - - -
Lay - - | - - - - | Lay - - - | - - - -
Lo - - | - - - - | Lo - - - | - - - -
Lee - - | - - - - | Lee - - - | - - - -



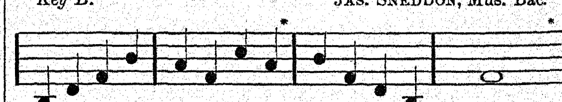
| m' : d' : s | m' : d' : s | d' : s : m | d' : s : m |
La - - - | - - - - | La - - - | - - - -
Lay - - | - - - - | Lay- - - - | - - - -
Lo - - - | - - - - | Lo - - - | - - - -
Lee - - | - - - - | Lee - - - | - - - -



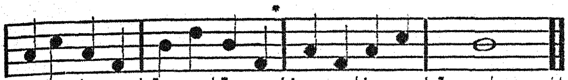
| s : m : d | s : m : d | r : d : t_1 | d : — : — ||
La - - - | - - - - | La - - - | - - - -
Lay - - | - - - - | Lay - - - | - - - -
Lo - - | - - - - | Lo - - - | - - - -
Lee - - | - - - - | Lee - - - | - - - -

Exercise 49.—DOH ON SECOND LEDGER SPACE BELOW.

Key B. JAS. SNEDDON, Mus. Bac.



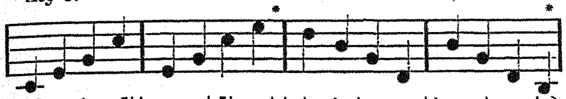
| d_1 : m_1 | s_1 : d | t_1 : s_1 | r : t_1 | d : s_1 | m_1 : d_1 | s_1 : — | — : — |
Koo, Koo, | &c.



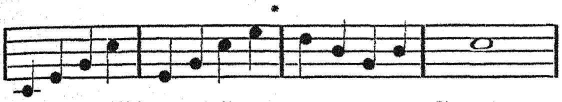
| t_1 :r | t_1 :s_1 | d :m | d :s_1 | t_1 :s_1 | t_1 :r | d :— | — :— ||
Koo, Koo, &c.

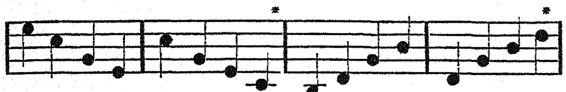
Exercise 50.—DOH ON FIRST LEDGER LINE BELOW.

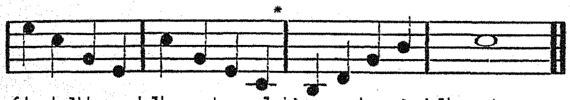
Key C. JAS. SNEDDON, Mus. Bac.



| d :m | s :d' | m :s | d' :m' | r' :t | s :r | t :s | r :t_1 |
Ah - - - - - - - - - Ah - - - - - - - - -



| d :m | s :d' | m :s | d' :m' | r' :t | s :t | d' :— | — :— |
Ah - - - - - - - - - Ah - - - - - - - - -

| m' :d' | s :m | d' :s | m :d | t_1 :r | s :t | r :s | t :r' |
Ah - - - - - - - - - Ah - - - - - - - - -



| m' :d' | s :m | d' :s | m :d | t_1 :r | s :t | d' :— | — :— ||
Ah - - - - - - - - - Ah - - - - - - - - -

The exercises and pieces hitherto given have been written either in two, three, or four-pulse measure. In two-pulse measure, we found that the accents were simply *strong* and weak, or *weak* and strong, a kind of time which might be illustrated by such words as—

| dawn- : ing, | think- : ing, | draw- : ing, &c.; or
: a- | wake, : a- | rise, : be- | ware.

Words of two syllables, beginning on the strong accent, give what is called the primary form of this measure; those beginning on the weak accent, the secondary form.

Four-pulse is very nearly related to two-pulse measure, the chief difference being that every alternate strong accent is changed into one of medium force. Words of four syllables, such as

| mo- : men- | ta- : ry, | sed- : en- | ta- : ry, &c.,

would convey to us some idea of the primary form of this measure. Any piece of music that did not begin with the strong accent would be in a secondary form. This kind of measure is often called common time.

In three-pulse measure (or simple triple time, as it is frequently called) the accents are *strong, weak, weak*, as in the words

| feel- : ing- : ly, | ten- : der- : ly;

or *weak, strong, weak*, as

: a- | larm- : ing, : be- | tray- : ing, : with- | draw- : ing,

and the like. The former give the primary, the latter the secondary form of this measure.

Six-pulse measure, which has now to be introduced, stands in much the same relation to three-pulse time as that of four-pulse occupies with respect to two; *i.e.* it provides for a rather quicker style of movement, and gives a medium for every alternate strong pulse.

| Spir- : it- : u- | al- : i- : ty, | pu- : sil- : la- | nim- : i- : ty,

words in which the accents may be described as *strong, weak, weak; medium, weak, weak*, may assist in conveying some conception of this kind of time or measure in its primary form. To begin on any but the strong or accented part would give a secondary six-pulse measure. Very frequently music written in this kind of time requires to be sung or played so quickly that we feel as if a kind of two-pulse measure were being performed, having every pulse divided into three equal parts. If the following couplet, viz.—

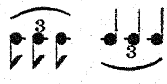
Beautĭfŭl bird ŏf thĕ wondĕrfŭl song,
Soarĭng ănd singĭng thĕ summĕr dāy long,

is rather smartly repeated, it will be felt that, with the exception of the last word in each line, the syllables run together in groups of three; and that it might be written either in six-pulse measure, thus—

| Beau- : ti- : ful | bird : of : the | won- : der- : ful | song : — : —
| Soar- : ing : and | sing- : ing : the | sum- : mer : day | long : — : —

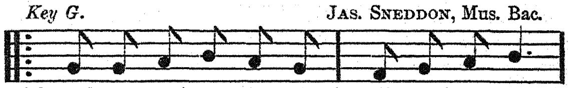
or in two-pulse measure, six of the pulses being broken up into thirds. Music for these words could therefore be written in either of the two ways, yet time, rhythm, accent, and sound would in each be the same. Exercise 51 is given in both.

In the ordinary notation, when three notes *of any kind* are to be sung in the time of two, a curved line, with the figure 3, is placed over or under them, thus— and they are called triplets, another word for thirds of a pulse or beat. The sign for thirds in tonic sol-fa is the comma *inverted*.

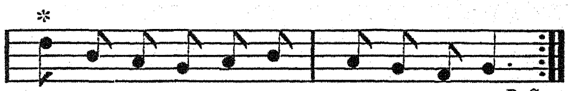


Exercise 51.—DOH ON SECOND LINE—ROUND IN TWO PARTS—SIX-PULSE MEASURE.

Key G. JAS. SNEDDON, Mus. Bac.



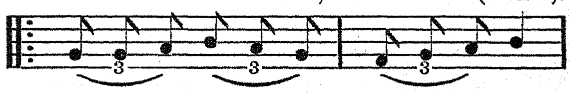
| d :d :r | m :r :d | t_1 :d :r | m :— :— |
Beau - ti - ful bird of the won - der - ful song.



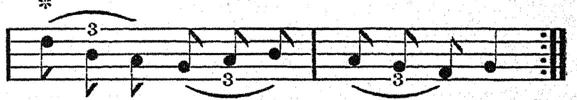
D.C.

| s :m :r | d :r :m | r :d :t_1 | d :— :— ||
Soar - ing and sing - ing the sum - mer day long.

THE SAME IN TWO-PULSE MEASURE, WITH TRIPLETS (THIRDS).



| d ,d ,r | m ,r ,d | t_1 ,d ,r | m |
Beau - ti - ful bird of the won - der - ful song,



D.C.

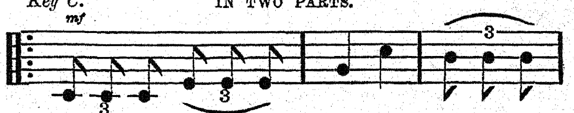
| s ,m ,r | d ,r ,m | r ,d ,t_1 | d ||
Soar - ing and sing - ing the sum - mer day long.

It will be felt, in singing, that the remarks concerning the relation of six to two-pulse measure apply with equal force to the next exercise, which is here given in two-pulse measure; but it would be beneficial for the student to endeavour to re-write it in six-pulse measure.

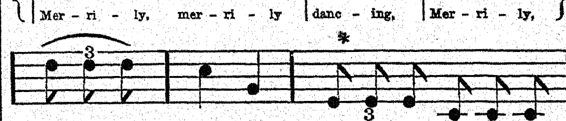
Exercise 52.—DOH ON FIRST LEDGER LINE BELOW—ROUND IN TWO PARTS.

Key C.

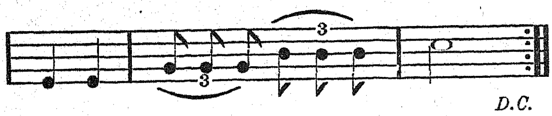
mf



| d ,d ,d :m ,m ,m | s :d' | t ,t ,t |
Mer - ri - ly, mer - ri - ly danc - ing, Mer - ri - ly,



| :r' ,r' ,r' | d' :s | m ,m ,m :d ,d ,d |
mer - ri - ly glanc - ing, Come the bright rays of the



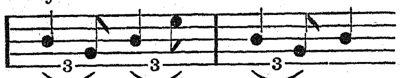
D.C.

{ | m :m | s ₑs ₑs :t ₑt ₑt | d' :— ||
morn - ing, Fill - ing all hearts with de - light.

In the preceding exercise, measures two, four, six, and eight are in two-pulse, and one, three, five, and seven, which appear in triplets (thirds), are examples of six-pulse measure. The latter is called the compound of the former.

In the two little pieces which follow, the rhythm runs more into the form of two pulses to one note and one to the next, which, in two-pulse measure, would require to be written as two thirds and a third; thus—

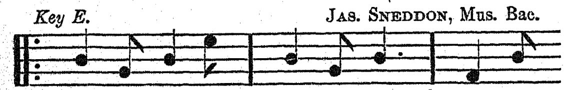
Key E.

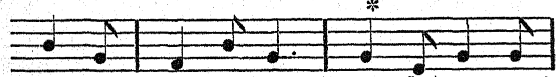


&c.

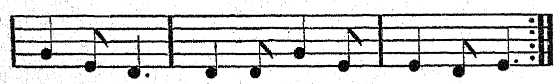
{ | s ₑ— ₑm : s ₑ— ₑd' | s ₑ— ₑm :s &c.

Exercise 53.—DOH ON FIRST LINE—ROUND IN TWO PARTS—SIX-PULSE MEASURE.

Key E. JAS. SNEDDON, Mus. Bac.

{ | s :— :m | s :— :d' | s :— :m | s :— :— | r :— :s }
Gent - ly on the west - ern wave, See the



{ | s :— :m | r :— :s | m :— :— | m :— :d | m :— :m }
sun re - clines his head, Faint - ly smil - ing,



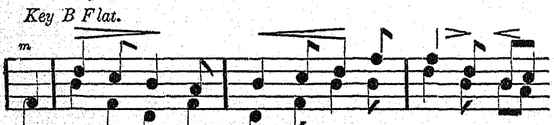
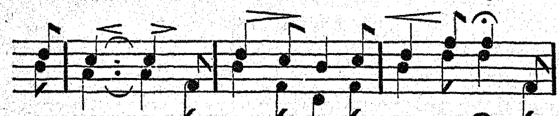
D.C.

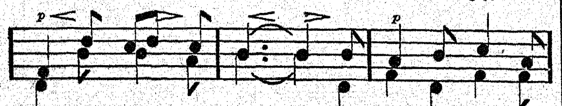
{ | m :— :d | t₁ :— :— | t₁ :— :t₁ | m :— :d | d :— :t₁ | d :— :— ||
as he laves, Pla - cid on his glass - y bed.

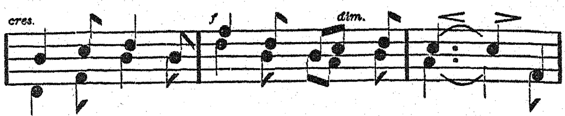
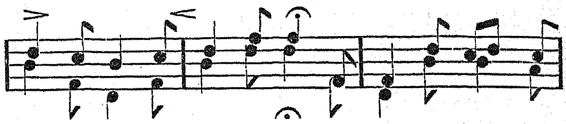
Exercise 54.—DOH ON THIRD LINE.

THE VALE OF CLYDE.

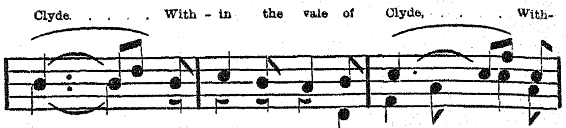
Words by JOHN STRUTHERS. JAS. SNEDDON, Mus. Bac.

Key B Flat.

{ | :s₁ | m :— :r | d :— :t₁ | d :— :r | m :— :s | s :— :m | d :r }
{ | :s₁ | d :— :s₁ | m₁ :— :s₁ | m₁ :— :s₁ | d :— :d | m :— :d | d :t₁ }
Ad - mir - ing na - ture's sim - ple charms, I left my hum-
I roam'd the braes o' bon - nie Doon, The wind - ing banks

{ :m | r :— :— | — :— :s₁ | m :— :r | d :— :r | m :— :s | s :— :s₁ }
{ :d | t₁ :— :— | — :— :s₁ | d :— :s₁ | m₁ :— :s₁ | d :— :m | m :— :s₁ }
ble home, A - while my coun - try's peace - ful plains, With
o' Ayr, Where flut - ters many a small bird gay, Blooms



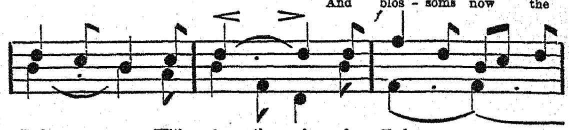
{ | s₁ :— :m | r :m :r | d :— :— | — :— :d | t₁ :— :d | r :— :t₁ }
{ | m₁ :— :d | d :— :t₁ | d :— :— | — :— :m₁ | s₁ :— :m₁ | s₁ :— :s₁ }
pil - grim steps to roam, I mark'd the leaf - y
many a flow - 'ret fair, But dear - er far to

{ | d :— :r | m :— :d | s :— :m | d :r :m | r :— :— | — :— :s₁ }
{ | m₁ :— :s₁ | d :— :d | m :— :d | d :t₁ :d | t₁ :— :— | — :— :s₁ }
sum - mer wane On flow - ing Ir - vine's side, But
me the stem That once was Cal - der's pride, And

{ | m :— :r | d :— :r | m :— :s | s :— :s₁ | s₁ :— :m | r :m :r }
{ | d :— :s₁ | m₁ :— :s₁ | d :— :m | m :— :s₁ | m₁ :— :d | d :— :t₁ }
rich - er far the robe she wears Within the vale of
blos - soms now the fair - est flow'r Within the vale of

Clyde. . . . . With - in the vale of Clyde, ... With-



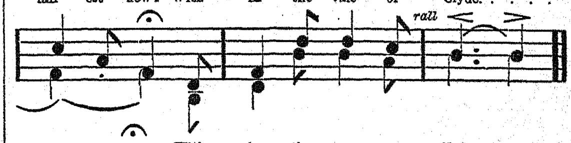
With-in the vale of

{ | d :— :— | — :m :d | r :— :d | t₁ :— :d | r :— :— | — :s :r }
{ | d :— :— | — :— : | : : | : :m₁ | s₁ :— :t₁ | r :— :t₁ }
Clyde. . . . . Within the vale of Clyde, ... With-
Clyde. Within the vale of

in the vale of Clyde, ... But rich - er far the
And blos - soms now the

Clyde, ... With - in the vale of Clyde. . . . .

{ | m :— :r | d :— :r | m : :— | — :— :m | s :— :m | d :r :m }
{ | d :— :— | — :— :t₁ | d :— :s₁ | m₁ :— :d | s₁ :— :— | — :— :— }
in the vale of Clyde. . . . . {But rich - er far the
Clyde, ... Within the vale {And blos - soms now the
of Clyde,

robe she wears With - in the vale of Clyde. . . . .
fair - est flow'r With - in the vale of Clyde. . . . .

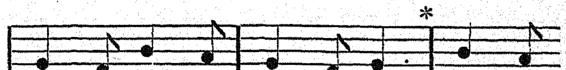


. . . . With - in the vale of Clyde.

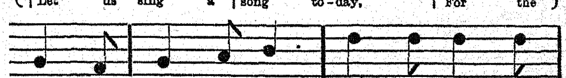
{ | r :— :t₁ | s₁ :— :m₁ | s :— :m | m :— :r | d :— :— | — :— ||
{ | — :— :— | — :— :d₁ | m₁ :— :d | d :— :t₁ | d :— :— | — :— ||
robe she wears With-in the vale of Clyde,
fair - est flow'r With-in the vale of Clyde,
With-in the vale of Clyde.

Exercise 55.—ROUND IN FOUR PARTS. DOH ON SECOND LINE.

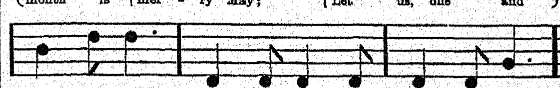
Key G. JAS. SNEDDON, Mus. Bac.



{ | d :— :t₁ | m :— :r | d :— :t₁ | d :— :— | m :— :r }
Let us sing a song to - day, For the



{ | d :— :t₁ | d :— :r | m :— :— | s :— :s | s :— :s }
month is mer - ry May; Let us, one and



{ | m :— :s | s :— :— | s₁ :— :s₁ | s₁ :— :s₁ | s₁ :— :s₁ | d :— :— ||
all, re - joice, Grate - ful heart and tune - ful voice.

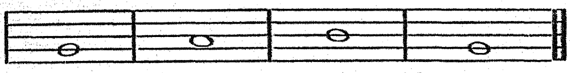
It will be readily understood by the intelligent student that notes shorter in duration than the quaver (the shortest note which we have as yet introduced) are not unfrequently used in music. A semiquaver, as its name implies, is only

half the length of a quaver, or, what is the same thing, one quaver is equal to two semiquavers, usually put thus— [quaver] = [two semiquavers]. Let it be observed that the semiquaver has two oblique lines or dashes attached to the stem, and the quaver has only one. Even so the sign for a semiquaver rest has two heads turned to the left, but the quaver has only one (p. 270). Exercise 56 is written in common time, *i.e.* four beats or pulses in the measure. In *a* we have semibreves only, each of which will get four pulses or beats. In the first three measures of *b* we have two minims getting two beats each. In the same measures of *c* the four crotchets will each get one beat. In *d* there are eight quavers in each measure; two of these will therefore go to a beat. In *e* sixteen semiquavers occur in the measure, four of which must go to a beat. In sol-fa language, this exercise is said to be written in notes of four pulses, two pulses, one pulse, halves, and quarters. It will be a good exercise for the student to set any simple kind of pendulum swinging while he endeavours to master this time-study. Let him proceed according to the method recommended at page 272, noticing carefully that one measure is sung in the same time neither more nor less than another. The sign for quarters in sol-fa is the comma in its usual form.

Exercise 56.—DOH ON SECOND LINE.

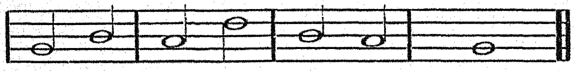
a. FOUR-PULSE NOTES.

Key G. JAS. SNEDDON, Mus. Bac.



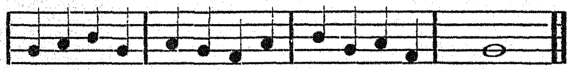
| d :— |— :— | r :— |— :— | m :— |— :— | d :— |— :— ||
La - - - - - - - - - - - - - - - -

b. TWO-PULSE NOTES.



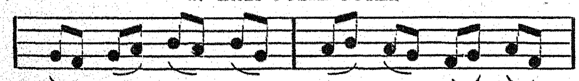
| d :— | m :— | r :— | s :— | m :— | r :— | d :— |— :— ||
La - - - - - - - - - - - - - - - -

c. ONE-PULSE NOTES.

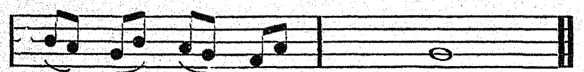


| d : r | m : d | r : d | t_1 : r | m : d | r : t_1 | d :— |— :— ||
La - - - - - - - - - - - - - - - -

d. HALF-PULSE NOTES.

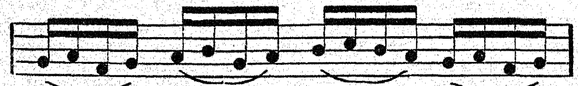


| d . t_1 : d . r | m . r : m . d | r . m : r . d | t_1 . d : r . t_1 |
La - - - - - - - - - - - - - - - -

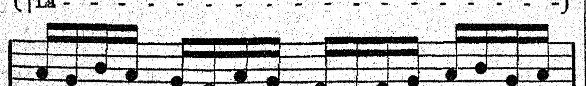


| m . r : d . m | r . d : t_1 . r | d : — : — | — ||
La - - - - - - - - - - - - - - - -

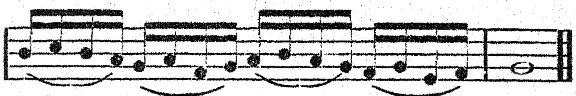
e. QUARTER-PULSE NOTES.



| d , r . t_1 , d : r , m . d , r | m , f . m , r : d , r . t_1 , d |
La - - - - - - - - - - - - - - - -



| r , d . m , r : d , t_1 . r , d | t_1 , l_1 . t_1 , d : r , m . d , r |
La - - - - - - - - - - - - - - - -



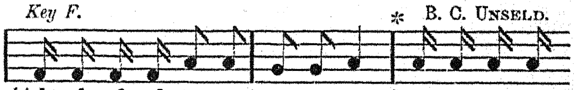
| m , f . m , r : d , r . t_1 , d | r , m . r , d : t_1 , d . l_1 , t_1 | d :— |— :— ||
La - - - - - - - - - - - - - - - - - -

The notes *fah* and *lah* (f and l) will be fully explained in the sequel.

Further illustration of quarter-pulses (semiquavers) will be found in the next two exercises.

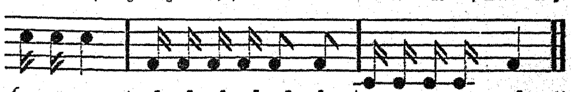
Exercise 57.—DOH IN FIRST SPACE. ROUND IN FOUR PARTS.

Key F. ✱ B. C. UNSELD.



| d , d . d , d : m . m | r . r : m | m , m . m , m |
Mer - ri - ly the bells are ring - ing near, Cheer - i - ly the

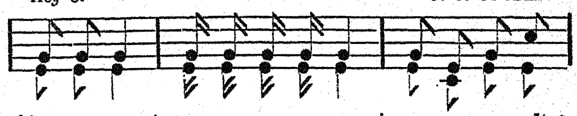
| s . s | t_1 . t_1 : d | s s . s , s : s . s | s , s |
birds are sing - ing here; List - en to the bells how mer - ri-

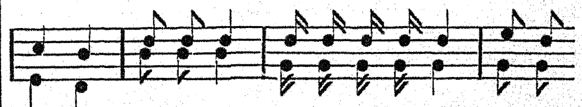


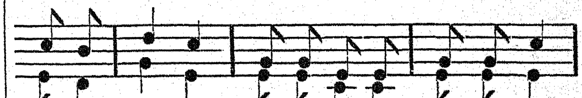
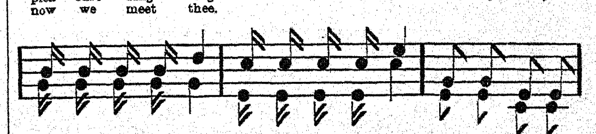
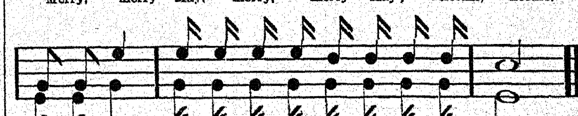
| s , s : s | d , d . d , d : d . d | s_1 , s_1 . s_1 , s_1 : d ||
ly they ring: List - en to the birds how cheer - i - ly they sing.

Exercise 58.—DOH ON FIRST LEDGER LINE BELOW.

LOVELY MAY.

Key C. B. C. UNSELD.

| s . s : s | s , s . s , s : s | s . m : s . d' |
| m . m : m | m , m . m , m : m | m . d : m . m |
Love - ly May, mer - ry, mer - ry May, Birdlets now are
Hap - py May, mer - ry, mer - ry May, With our songs we



| d' : t | r' . r' : r' | r' , r' . r' , r' : r' | m' . r' :
| m : r | t . t : t | s , s . s , s : s | s . s :
sing - ing, Ev' - ry - where thro' the balm - y air Songs of
greet thee; On the hill, by the shin - ing rill, Glad - ly

| d' . t | r' : d' | s . s : m . m | s . s : d' |
| m . r | s : m | m . m : d . d | m . m : m |
plea - sure ring - ing. Welcome, welcome, love - ly May.
now we meet thee.

| t , t . t , t : r' | d' , d' . d' , d' : m' | s . s : m . m |
| s , s . s , s : s | m , m . m , m : d' | m . m : d . d |
Merry, merry May, merry, merry May; Welcome, welcome,

| s . s : m' | m' , m' . m' , m' : r' , r' . r' , r' | d' :— ||
| m . m : s | s , s . s , s : s , s . s , s | m :— ||
love - ly May. Merry, merry, merry, merry May.

TIME SIGNATURES.

In the ordinary notation various signs and numerals are employed, and one or other of them placed at the beginning of every piece of music to denote the kind of time or measure in which it is written. This is called the "time signature." For four-pulse measure the sign most generally used is the letter C, which letter appears so frequently that the style of movement which it represents is called common time. It tells that there are to be four beats or pulses in the measure, and that a crotchet or its value is to go to a beat. Exercises 49, 50, 56, and others, are therefore written in common time.

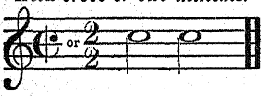
Instead of the letter C the figures $\frac{4}{4}$ placed one over the other are sometimes used. These serve the same purpose, for the upper figure tells us that we are to expect four beats or pulses in the measure, and the under figure says that the value or duration of each pulse is to be the fourth of a semibreve. This is the rule wherever figures are employed, viz. the upper figure always points to the number of beats in the measure, and the under one explains the relation of each beat to the semibreve, which, for this purpose, is taken as the note of standard duration or time measurement. Thus the figures $\frac{2}{2}$ would show, first, that we were to expect two beats in the measure, and second, that each beat was to be equal in value or duration to a minim. This measure is not unfrequently shown by the letter C with a line drawn through it, thus 𝄵, when it is called *alla breve* time. The figures $\frac{2}{4}$ would indicate that two crotchets (two-fourths of a semibreve) were to be looked for.

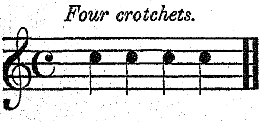
Every kind of measure is divisible into two kinds, viz. *common* and *triple* time. When the number of beats in a measure can be divided by *two*, we have always what is understood by the general name of common time; when such beats can be divided by *three*, we have triple time. Each of these kinds of time is again subdivided into *simple* and *compound*. Simple, common, or triple measures are those in which the pulses or beats maintain their original value; the compounds of these are formed by adding a dot to each beat, *i.e.* making it one-half longer. Underneath is a

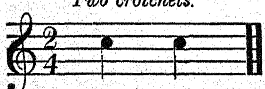
TABLE OF TIME SIGNATURES.

SIMPLE COMMON TIMES.

Alla breve or two minims.

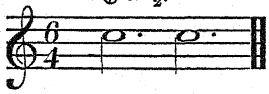


Four crotchets.

Two crotchets.

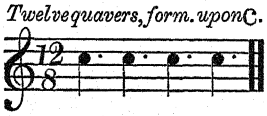


COMPOUND COMMON TIMES.

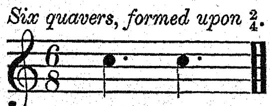
Six crotchets, formed upon 𝄵 *or* $\frac{2}{2}$.



Twelve quavers, form. upon C.

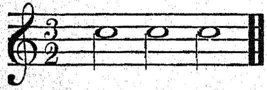


Six quavers, formed upon $\frac{2}{4}$.

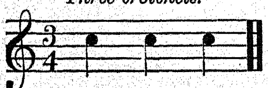


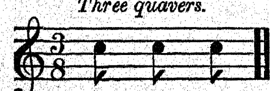
SIMPLE TRIPLE TIMES.

Three minims.

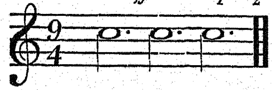


Three crotchets.

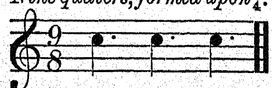


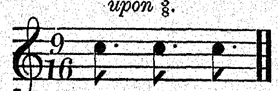
Three quavers.

COMPOUND TRIPLE TIMES.

Nine crotchets, formed upon $\frac{3}{2}$.



Nine quavers, formed upon $\frac{3}{4}$.



Nine semiquavers, formed upon $\frac{3}{8}$.

A few additional time signatures may occasionally be seen, especially in old music, but the foregoing rules always apply, and the above examples include all those which are in ordinary use. Notice particularly that when figures are used the compound of any simple time may be found by multiplying the upper figure by three, and the under figure by two.

DRAWING.—CHAPTER II.

MODEL OR OBJECT DRAWING—GEOMETRIC AND NATURAL FORMS—PERSPECTIVE—NATURE-STUDY.

THE drawing of objects, or (as it is called by the Science and Art Department) *model drawing*, is one of the most important branches of elementary art-study. The term is somewhat narrow and misleading. We might suppose from it that this is the art of drawing geometric models. This would be only partially correct; for the government examiners do not restrict themselves to this idea, but have given as subjects for this examination such real things as wheelbarrows, water cans, tubs, and the like, which can scarcely in any sense be called "models." Object drawing is a far better term for this class of work, and looked at in the light of this designation it will be seen that it brings before us a very wide course of study indeed. Everything we are ever called upon to draw might be said to be an "object." The term "model drawing" is not only misleading but positively repellent. The average student's notion of it is the drawing of cubes, prisms, cylinders, &c., and it is difficult indeed to see the connection between this unattractive work and the delightful study of art which they had proposed to themselves to follow.

Few things are less attractive at first sight than a cube—it is so very rectangular and uniform, and the possibilities in the way of variety it affords are apparently so small. There seems no chance of becoming interested in the drawing of cubes, or of getting any one else to be interested in it when the drawing is done. If a student begins the study of model drawing—with the prospect of spending a long term in preparing for an examination—without a proper knowledge of the ultimate usefulness of all this work, it is no wonder that he should feel inclined to "give it up in despair."

But if these cubes, prisms, and blocks be seen to be the most simple and elementary examples of objects, and the student learns that they are given as examples because they *are* very simple forms; if he be further taught to note in these simple blocks the fundamental forms of more interesting objects—then "model drawing" will be joyfully pursued, as being the absolutely necessary groundwork of all proper study of form. So essential is this drawing of simple objects that some authorities on art have considered it to be the only branch which a student should follow, and have advised commencing at once by drawing *things*, without any previous practice in drawing from *copies*.

Mr. Ruskin, with characteristic originality, says in his "Elements of Drawing," "Go out into your garden, or into the road, and pick up the first round or oval stone you can find," and advises his reader to begin his art studies with drawing this stone; "for," he says, "if you can draw that stone *rightly* you can draw anything."

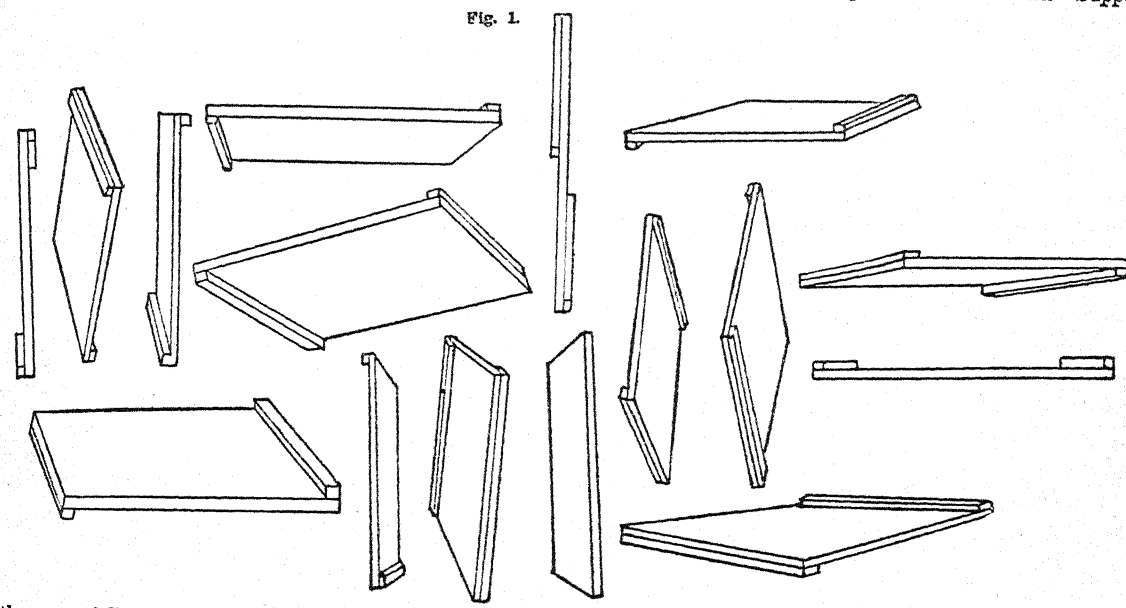
He shows the student that in the cracks and fissures of the stone he has in miniature the hollows and ravines of a mountain side, and quite the same reasoning may be applied to the geometric models used in schools for the teaching of object drawing. When the student sees that in the lines of these simple and unattractive models he has the fundamental lines of the more advanced objects that he longs to be able to draw—that the lines of a pyramid, for instance, are exactly similar to those of a church spire, and a prism very like a tower—then the fact that a thorough course of model or object drawing may be advantageous to that end will be evident.

The observant student will often be surprised at the numerous forms which a very simple object may assume when placed in various positions in relation to the eye. Here in

fig. 1 are a few of the possible appearances of an ordinary drawing board. It will be seen from these sketches that the number of appearances which the very same object, differently placed, may assume may easily be thought of as infinite. An intelligent person will probably ask, How do we get such a variety of appearances? We shall attempt to answer this very proper question.

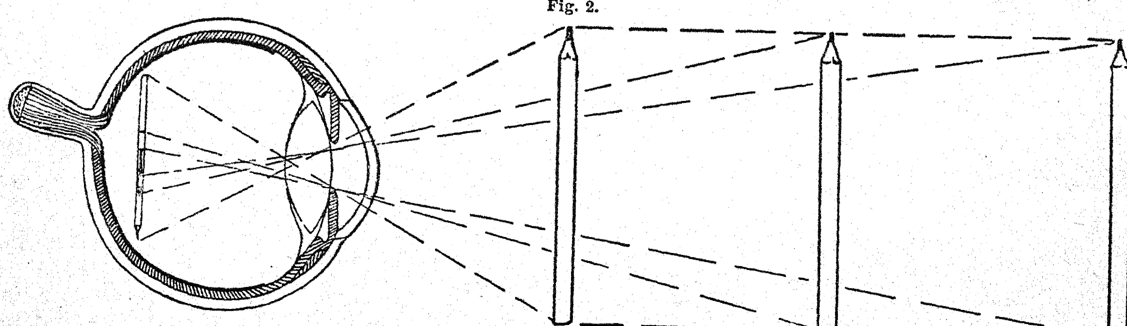
Light travels in straight lines, called rays, from some source, such as the sun. These rays of light fall upon the various objects around us. These objects not only receive but they also reflect light. That is, the rays of light which fall on an object are reflected or thrown back from it. We may therefore say that we see all things by means of rays or supposed lines of light which proceed from the things themselves. These rays fall upon and enter into the eye; the eyeball being round, or nearly so, the rays fall upon it as shown in the subjoined sketch (fig. 2). It is not necessary here to show the exact physiological action of sight. That is explained in NATURAL PHILOSOPHY (*Optics*) and in PHYSIOLOGY. It is sufficient to point out the results. Suppose

Fig. 1.



the rays of light to proceed from a black-lead pencil; they come from every part of it, but we need only speak of two—one from the top and one from the bottom of the pencil. These two rays converge and enter the eye. Upon the back part of the eyeball, called the retina or receiving plate, we get the image—in other words, the appearance—of the object we are looking at. This *appearance* we must try to imitate in our drawing, and if we carefully study the diagram given we shall see that this appearance will change as we move the object nearer to or further from the eye. Following the rays from the pencil at first position we find that they cross each other, in the eye, at a certain angle, and give a rather large image on the retina; the rays from the second pencil cross at a smaller angle, and give a less image; the third position still less; and if the pencil be removed to a sufficient distance the image will become a mere point; after that it will pass or "vanish" out of sight. This point is called in *perspective* the "vanishing point." Turning now to nature and taking a row of tree trunks or a row of pillars instead of a row of pencils, we see how they appear gradually to decrease in height as they recede from the spectator, and how the parallel lines connecting them appear to approach each other, or converge. If we had a row sufficiently long the most distant pillar (fig. 3) would finally disappear or "vanish," and

Fig. 2.



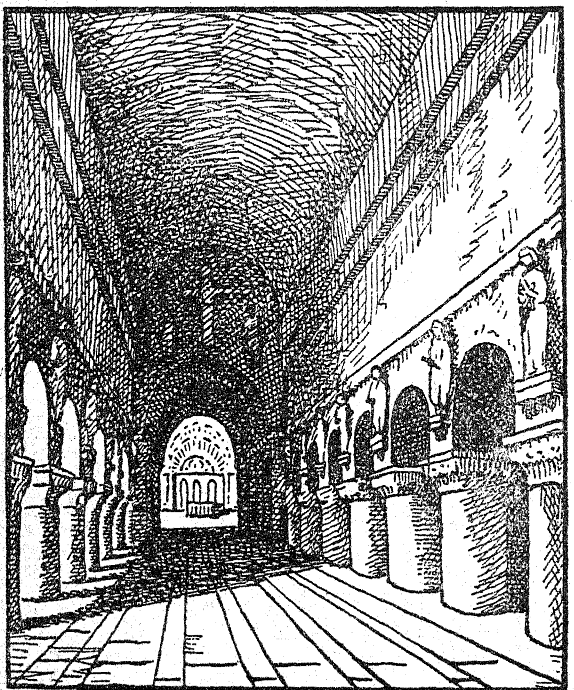
the parallel horizontal lines would seem to us to meet in a "vanishing point."

Similar visual phenomena are constantly impressing us, but few notice them, because of their familiarity. This decrease in apparent size of objects, and consequent converging of connecting lines, can be seen in almost any street by looking at the lines of the houses and footpaths, or the lamp posts, or on a railway platform by noticing the lines of the rails as they narrow to the eye in the distance; any good drawing or "photo" of such places will show the same results. Although, however, these appearances are so evident in long streets and in drawings which represent hundreds of feet of space, they are not so plainly apparent in smaller objects. Therefore the student often fails to see them, yet as a matter of logical reasoning it follows that if the lines of the railway or of the footpath look narrower half a mile away than they do near to us, they must *begin* to get narrower in appearance in the first few inches, and therefore that in an object only a foot or so long the lines which recede from the eye must begin in the impression they make on the retina to converge. We suppose that a student has sat down to sketch an object. As these instructions are intended for students who have not

the opportunity of attending classes, as well as those who have, we will suppose the object to be a box, the nearest approach to a *cube* within the reach of all.

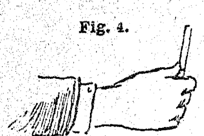
The box should be placed at a reasonable distance from the eye—say 6 or 8 feet—and the student should sit *facing*

Fig. 3.



it, as shown in fig. 5. The first line placed upon the paper should be the nearest upright corner of the box; and as students often ask the question, "How shall I begin?" we may give this as a general rule:—Begin with the nearest *vertical* line if there be but one object; and if more than one, draw the largest object first, grouping the smaller ones round it in proper relation as to position and size.

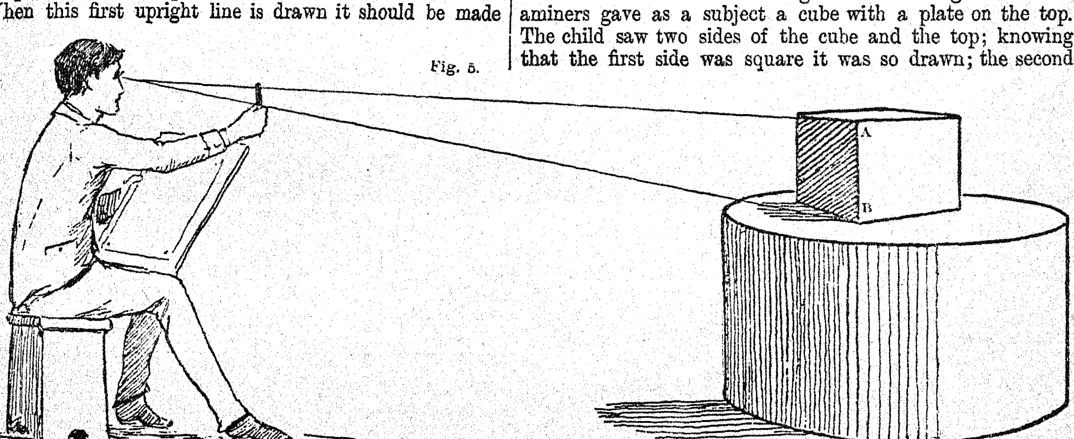
Fig. 4.



When this first upright line is drawn it should be made a easonable size—not less, say, than 3 inches high; for this line will be the standard or scale in proportion to which all the other lines will be drawn. If therefore it be made too small, the whole drawing will of necessity be also too small. Taking this line, then, as the standard, it will be necessary to *measure* the relative size of the other lines. The method of measuring the comparative size of the parts of an object is somewhat hard to understand, and rather difficult to explain. But as it is desirable, if not absolutely essential, that this measuring should be done, the student should read the following instructions carefully:—The pencil should be taken in the hand as shown at fig. 4, and held between the eye and the object so that the top of the pencil coincides with the top of the line A B; the thumb should then be slowly moved down the pencil until it coincides with the bottom of the line, B (that this may be properly seen one eye should be closed); the line A B will then be represented by a space on the pencil from thumb to top. If now the hand be moved forward, *i.e.* nearer to the object, this space will appear to increase; if brought nearer to the eye it will decrease. To avoid this variation the hand should be held at precisely the same distance from the eye—say at arm's length. The first line, A B, having been measured in this way, the pencil should be moved to the upright lines on the right and on the left. They will be found to be shorter—thus proving the accuracy of the law of optics which has just been explained (figs. 2 and 3), namely, that lines appear to decrease in size when placed further from the eye. The horizontal lines or edges of the box which connect these upright lines will therefore converge or approach each other. The distance across the top of the box should next be measured and compared with the height at A B —the pencil being kept *always* level with the student (in technical phrase, parallel to the picture) and not put level with the parts of the object. The height being so measured it will be found that the distance from end to end of the box, across the top, appears to be very much less than the height at A B, although it is in reality very much larger.

Beginners constantly tend to make spaces similar to the top of this box too large, and it is only after much instruction and practice that the space is represented at its proper size. This is due to the fact that the student is tempted to draw from his *knowledge*, and not from and in accordance with the impressions of sight. He cannot, at first, believe it possible that the large rectangular top of the box should appear to be such a very narrow space. A remarkable instance of this tendency was shown by a child at an examination held in "model drawing" some time ago. The examiners gave as a subject a cube with a plate on the top. The child saw two sides of the cube and the top; knowing that the first side was square it was so drawn; the second

Fig. 5.

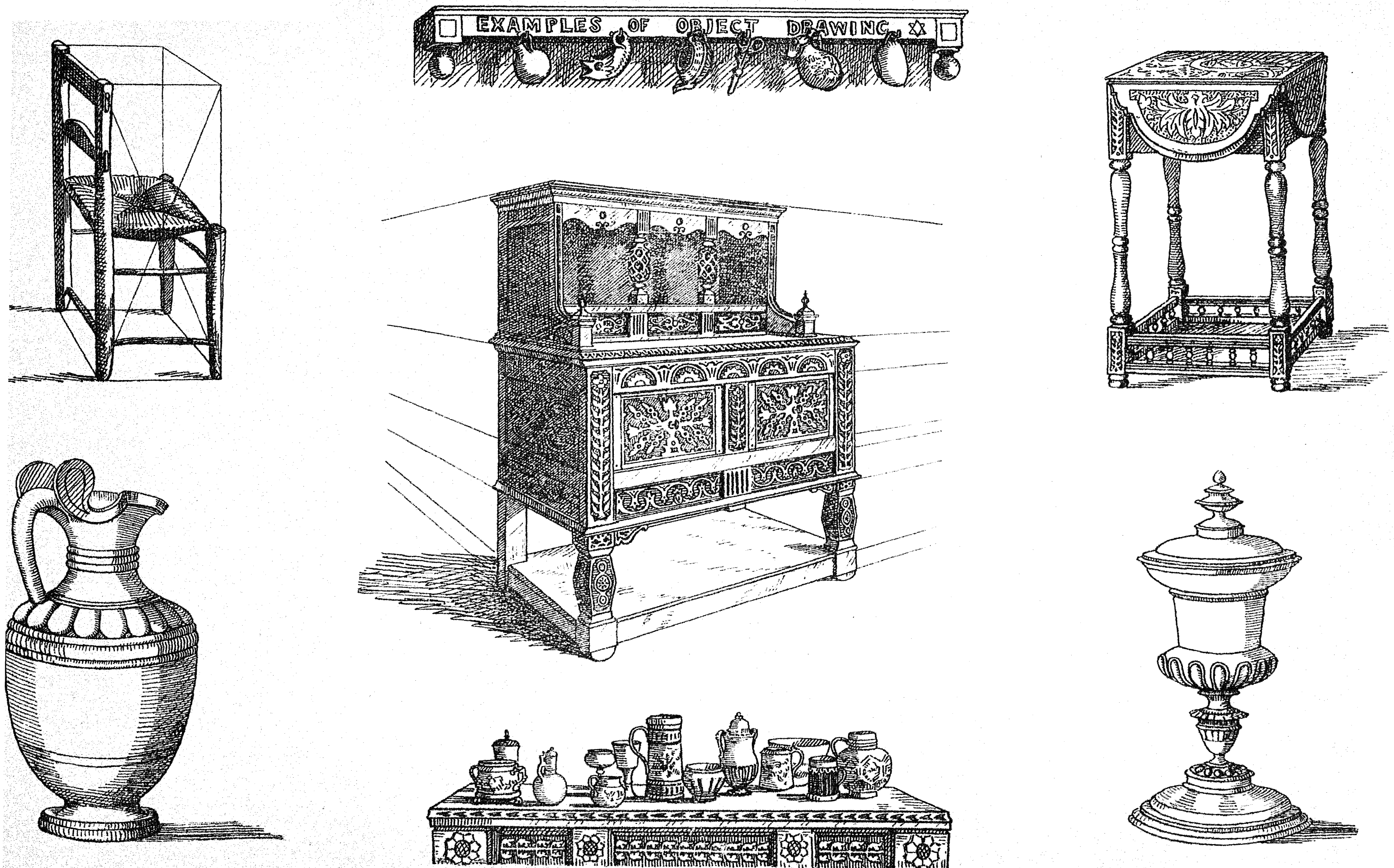


was also drawn as a square by the side of the first; and the top being known to be similar to the sides was drawn like them. Of course the child knew that a dinner plate was round, and therefore a circle was placed in the square representing the top of the cube. Some may smile at such an absurd result as that show in fig. 6, but almost every beginner makes a similar error, only in a less degree. In the same figure there is a drawing of the two objects (No. 2) such as would be made in hundreds of cases by students who have had some instruction in model drawing, and yet it is only a little less wrong than No. 1, and a little nearer the right, as shown at No. 3.

After drawing the box in the position shown at fig. 5, it should be placed up on its end and have the lid opened at various angles. Then an endeavour might be made to draw

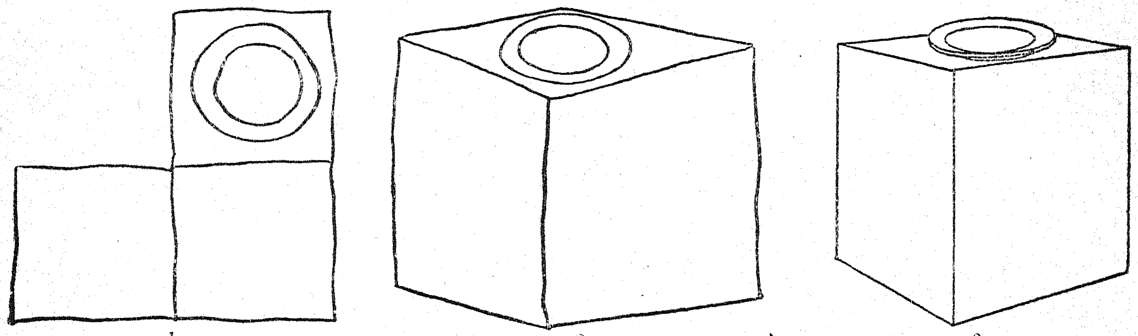
DRAWING.

PLATE III



the door of a room and the surrounding doorcase, the door being opened at various angles. Next a large square cupboard or chest, opening the lid or the doors or drawers. Several drawings of each object should be made in various positions, constantly comparing the length of the lines in the method above described, and also noting carefully the *direction* of lines by holding the pencil, or perhaps better still, the edge of the drawing board, horizontally or vertically against them, and looking along this edge with one eye. In all these more elaborate objects—chests, cupboards, &c.—the details will nearly always follow the lines of the general shape, as shown at Plate III. If the student should find any difficulty

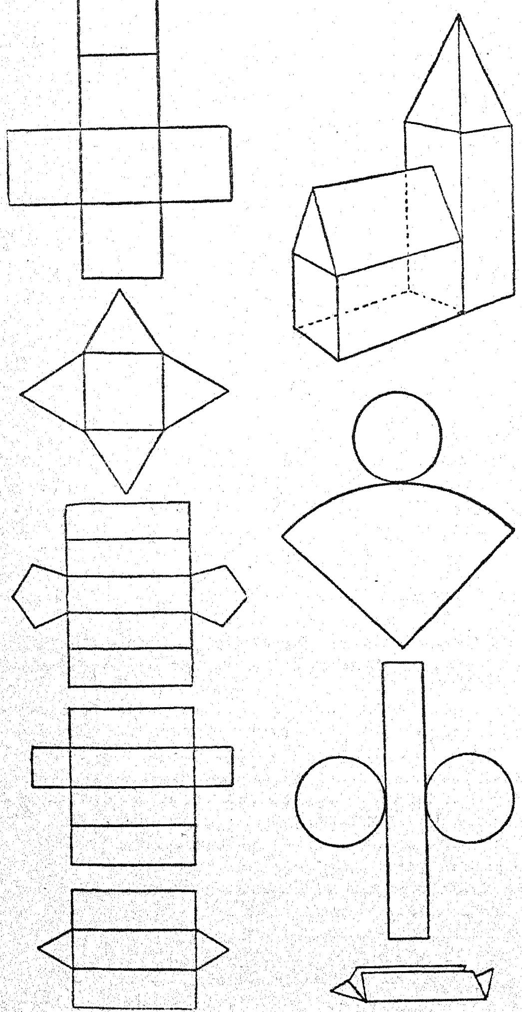
Fig. 6.



1 2 3

in obtaining simple forms for practice they can be easily made out of cardboard, or even stiff paper, in the following manner:

Fig. 7.



—Shapes similar to those given at fig. 7 should be cut out in card or paper, and the lines shown in the figures marked upon them. If card be used these lines should be slightly cut with a knife, then the card or paper doubled or folded up, as shown in one of the figures, and the edges fastened together with a little gum. These objects might be combined in groups so as to make fair imitation of well-known architectural forms, as shown at same figure.

We have hitherto spoken only of rectangular or straight-lined objects. We now proceed to give some directions for the drawing of circular objects, or objects with curved lines. It will be well to begin with a circular piece of card about the size of a dinner plate. This should be drawn in various positions. It will soon be discovered, if rightly set about, that there are only three forms which the circle can possibly assume—1, a true circle; 2, a line; 3, an ellipse, which will be wider or narrower according to the view we have or take of the circle. In most cases we shall get this appearance of an elliptical shape; very seldom indeed does it yield that of the line or the true circle. To draw this ellipse correctly it will first be necessary to get its two diameters or *axes*—the shorter one called the *minor* axis, and the longer one called the *major* axis. It will be found the best way to draw these at right angles to each other, and then to try to draw the ellipse through the points forming the ends of the axes. An ellipse is a difficult form to draw, and should be attempted with great care. When a student has made about a dozen drawings of the circular card a more complicated object may be taken, such as a large milk pan or water jug; these objects really consist of a series of circles with a few connecting lines. These circles should be looked for and drawn first, the experience gained by the study of the card being made use of in this case.

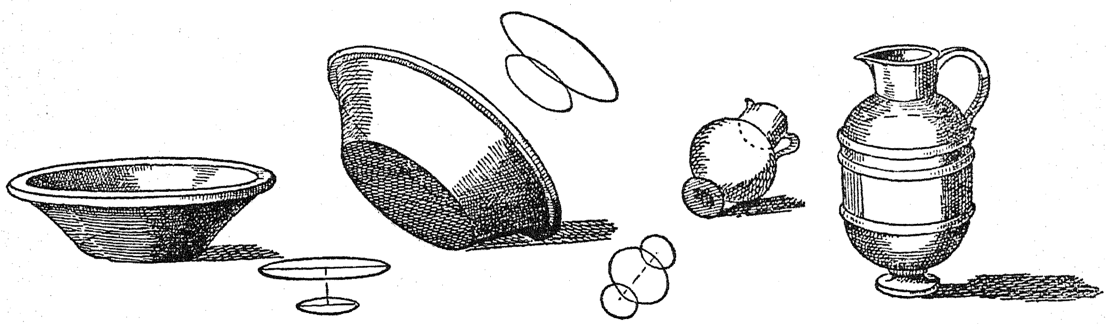
The circles used in constructing the drawings are here shown (fig. 8) side by side with the drawings themselves. In some cases very few connecting lines are necessary. When the object is upright a straight line should first be drawn for the centre. This central line will be found very useful. When the object is inclined it should be used as an axis, round which the whole form should be carefully balanced.

These sketches are slightly shaded, for it is really impossible to express the roundness of forms in certain positions by a mere outline drawing; a cylinder, for example, when right opposite the eye would appear as a simple rectangle, and the fact of its roundness cannot be shown without shade. The student should not be disappointed therefore if he finds that after all his care in drawing a round object it will not look as if it were sound. Light and shade must be employed to give the true effect of roundness. It is desirable, however, to work in outline at first, for two reasons—first, because it is a necessary training for the government examinations; and secondly, because light and shade is a very important branch of art work, and should not be attempted without some direction such as we hope to give in a future article.

The number of objects which may be taken as drawing models is almost infinite, but as it is sometimes difficult to

decide what to choose out of the many which we have around us, the following may be taken as examples suitable for the purpose:—(1) Books in various positions, opened and closed. These should be taken as oblong blocks first, and afterwards all the details of the binding may be added except the lettering; when closed the leaves of the book should always be treated as one mass. (2) Most of the things on a breakfast table; cups, saucers, and basins especially make excellent examples. (3) Many kitchen utensils, such as pans, bowls, candlesticks, and boxes, are also useful; and out of doors, (4) tubs, wheelbarrows, gates and gate posts, steps, benches, buckets, and scores of other objects besides those of which specimens have been given in these pages. All these form excellent studies for the earnest and industrious student; all will repay the effort requisite to reproduce them, and each will contribute to the knowledge, experience, and dexterity of the patient and industrious spirit who gives his days and his nights to the acquisition of the practical power of drawing.

Fig. 8.



TRIGONOMETRY.—CHAPTER IV.

SINES AND COSINES AND THEIR RELATIONS—THE CORRELATIONS OF SIDES, ANGLES, ARCS, ETC.

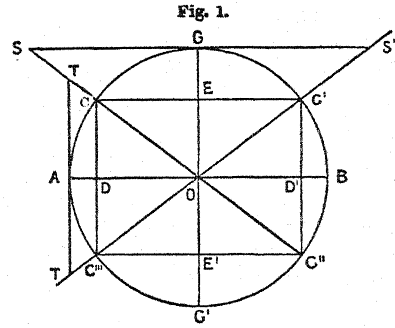
The true test of knowledge is the ability to use it. To see in the midst of a considerable intricacy of phenomena, the special fact to which investigation ought to be given, and to trace that fact in its relations and consequence as clearly and as far as possible, are evidences of knowledge really acquired and properly pursued. Hence we purpose, having laid before our readers so much of the main matter of trigonometrical theory, to present an instance of the entire working out of a definite problem through all its chief relations, and so to test the perceptive power acquired by the student of our former chapters of following out into a consecutive course of reasoned research the matter therein placed before him. In the process of resolving the distinct problem, we shall carefully explain each step taken, and clearly define each line referred to, in such a way that the student who follows the course of the demonstration presented to him will readily understand how —proceeding by inspection, and guided by the instructions already given—he may pass from one fact to another, aided by accurate reasoning, close calculation, and those happy contrivances which, according to wisely accepted convention, have been made familiar to us, and be enabled to determine the several parts of a plane triangle from certain elements of that same triangle given in experience or accepted by agreement. The problem which we propose to submit to special inspection, examination, and explanation is one involving the foundations of trigonometrical science, and affording the groundwork, if intelligently understood, of all the propositions that are essential for the solution of plane triangles.

PROBLEM. *The sine and cosine of an arc being given, to find the tangent, cotangent, cosecant, and versed sine of that arc.*

We first present an illustrative figure, bringing vividly before the eye the several essential trigonometrical lines—as they have been defined at p. 96—in their proper relations one to another. Let the construction be, say, as follows:—Describe a circle A G B G′ (fig. 1) with the radius O A, which take as equal to *unity*. Make A C the arc which measures the angle A O C, and having the usual defined relation to the right angle A O G. From the point C we may next let fall the perpendicular C D upon the radius O A, and also the perpendicular C E upon the radius O G. From the point A, the extremity of the radius O A, let us raise the perpendicular A T, prolonged so as to meet the line O C, and also let the perpendicular G S be raised from the point G, the extremity of O G, extended also so as to meet the line O C, prolonged so as to meet it at S.

This gives us (1) C D as the *sine*, *i.e.* the first certain element of our investigation—for the sine of an arc, or of the

Fig. 1.



angle which it measures, is a straight line drawn from one end of that arc to a diameter passing through the other end of the same arc; and (2) C E, the *cosine*, because it is the sine of C G, the complement of the arc A C—in other words it is that part of the radius contained between the centre of the circle and the touching point of the sine; and hence C E equals O D. Whence we see (1) that the cosine of an arc equals the cosine of its supplement; and (2) that neither the sine nor the cosine of an arc can ever exceed the radius.

Having made sure of what is *given* us, let us make ourselves equally certain as to what we are to *find*. These are (1) the *tangent*, that is, a right line touching the circle in the beginning of the arc, and produced thence till it meets the radius (extended) that is drawn through the other end of the arc, as A T touching O C extended to S does; (2) the *secant*, that is, the straight line drawn from the centre of the circle which, cutting the circumference, meets the tangent, as O T does; (3) the *cotangent*, that is, the tangent of the complement of an arc, as G S is; (4) the *cosecant*, that is, the secant of the complement of an arc, as O S is; and (5) the *versed sine*, that is, the part of the radius of an arc which lies between the sine and the arc, as A D is. Besides this finding of the secant and cosecant, we may easily see that these lines always exceed the radius, and that the tangent and cotangent may vary through all possible degrees of magnitude.

The mere inspection of the figure will show us (1) that the triangle O D C, formed by the *radius* O C, the *sine* C D, and the *cosine* O D, is a right-angled one. Hence the right-angled triangle O C D is formed by lines which hold to one another (Euclid I. 47) the following relations—viz. $OC^2 = CD^2$

$+ OD^2$, or employing the algebraic notation and denoting the radius by r, we have $r^2 = \sin^2 a + \cos^2 a$ (a denoting the angle A O C); (2) that the triangle (right-angled) formed by the secant O T, tangent T A, and radius O A—that is, O A T, is a similar triangle—as is also (3) that formed by the cosecant O S, the cotangent G S, and the radius O G, that is, the triangle O G S. From these facts of observation we deduce these facts of relation—the triangle O A T gives $OT^2 = OA^2 + AT^2$, or $\sec^2 a = r^2 + \tan^2 a$; and the triangle O G S gives $OS^2 = OG^2 + GS^2$, or $\operatorname{cosec}^2 a = r^2 + \cot^2 a$.

Besides these more direct deductions, we can realize to ourselves these further facts, and express them in similar formulæ—viz. Between the similar triangles O D C, O A T, the following relations appear, O D : O A :: D C : A T, that is to say, that $\cos a : r :: \sin a : \tan a$, and therefore that $\tan a = \frac{r \sin a}{\cos a}$. But again we can say, as O D C, O A T, are similar triangles, O D : O A :: O C : O T, which is expressed thus, $\cos a : r :: r : \sec a$; and thence $\sec a = \frac{r^2}{\cos a}$.

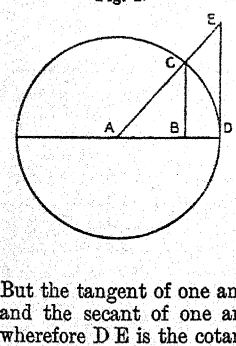
Once more, O A T and O G S are similar triangles; hence A T : O A :: O G : G S, which yields the following expression, $\tan a : r :: r : \cot a$; therefore $\cot a = \frac{r^2}{\tan a}$. Again, O E C and O G S are similar triangles, and therefore O E : E C :: O G : G S, which otherwise expressed gives the formula, $\sin a : \cos a :: r : \cot a$, and therefore $\cot a = \frac{r \cos a}{\sin a}$. Still further, O E : O C :: O G : O S; this is formulated $\sin a : r :: r : \operatorname{cosec} a$, wherefore $\operatorname{cosec} a = \frac{r^2}{\sin a}$.

It may be as well here to observe that of the eight possible trigonometrical lines, the following are called *direct*—viz. the sine, the tangent, the secant, and the versed sine of an angle or arc; and the following *indirect*—viz. the sine, the tangent, the secant, and the versed sine of the complement of that angle or arc —in other terms, the cosine, cotangent, cosecant, and coversed sine. In general, it may be said that whenever we gain any known relation between the *direct* and the *indirect* trigonometrical lines of an arc, we can form a new one by simply changing the direct lines into lines which are indirect, correspondent, or reciprocal.

The most practical point to be considered is how we may best bring the different sides of right-angled triangles into such relations as subsist among trigonometrical lines. This may be readily done by making any side of a rectangular triangle the *radius* of a circle; for then the other sides will necessarily become sines, tangents, or secants. Let us see.

1. In the rectangular triangle A B C (fig. 2), let the hypotenuse be made the radius of the circle C D. It is clearly seen that B C is the *sine* of the angle A, and that A B is its *cosine*.

Fig. 2.



Now we know that as the acute angles of a rectangular triangle are together equal to a right angle, and are therefore the complements of each other, the sine of either is the *cosine* of the other, and *vice versa*, and hence B C is the cosine of the angle C, and A B is the sine.

2. If, in the right-angled triangle A D E (fig. 2), the base A D is considered as the radius of the circle C D, the tangent of A is plainly D E, and A E is the secant. But the tangent of one angle A is the cotangent of the other, and the secant of one angle is the cosecant of the other, wherefore D E is the cotangent of E, and A E its cosecant.

3. If the perpendicular E D is regarded as the radius, D A is the tangent of the angle E, and the hypotenuse A E will be its secant. As, however, the tangent, secant, &c., of one angle of a right-angled triangle is the cotangent, cosecant, &c., of the other, the base A D will be the cotangent of the angle A, and the hypotenuse A E will be its cosecant.

These examples being fully understood, little else will be required to prove the following

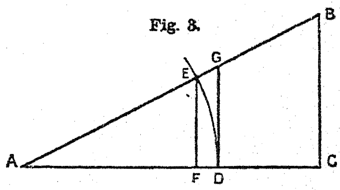
Proposition. *In any right-angled plane triangle, if any of the three sides be made the radius of a circle, the other sides will be either sines, tangents, or secants, of the angle correspondent to that radius.*

There can be no triangle given to which a similar cannot be constructed. Hence, as the sides of similar triangles are proportional, we can see the correctness of the following

Theorem. *In any right-angled triangle* (1) *the radius is to the sine of either of the acute angles as the hypotenuse is to the side opposite to that angle; and* (2) *as the radius is to the tangent of either of the acute angles, so is the side adjacent to that angle to the side opposite to it.*

Let A B C (fig. 3) be a rectangular triangle, having the right angle at C. With centre A and radius A D describe the circle D E. Let fall the perpendicular E F upon A D, and from the point D, touching the circle D E, raise the perpendicular D G. Then E F is the sine of the angle A, and D G is its tangent.

Fig. 3.



The two triangles A E F and A G D, are evidently similar to the triangle A B C, and therefore A E : E F :: A B : B C, or $r : \sin a ::$ A B : B C; and A D : D G :: A C : B C, or $r : \tan a ::$ A C : B C.

If we refer to the preceding proposition we may reason thus:

1. If the hypotenuse is the radius of a circle D E, then the radius A E : the hypotenuse A B :: E F, the sine of the angle A and the cosine of the angle E : the base B C; and again, the radius A D : the hypotenuse A B :: the sine of angle A and cosine of angle E : the perpendicular B C.

2. If the base is made the radius of the circle, then A B C and A D G are similar, and therefore A B : A G :: A C : A D, and A B : A G :: C B : D G; in other words, A B, the secant of the angle A (which equals the cosecant of the angle B), holds the same relation to the hypotenuse A G as does the radius A C to the base A D; and this same A B (secant of A and cosecant of B) holds the same relation to the hypotenuse A G as C B (tangent of A and cotangent of B) does to the perpendicular D G.

3. If the perpendicular is regarded as the radius of a circle, then A E F and A B C are similar, and the proportional lines are A E : A B :: A F : A C, and E A : B A :: E F : B C. That is, A E, the secant of E and cosecant of A, is similarly proportioned to the hypotenuse A B as is the tangent of E and the cotangent of A (*i.e.* A F) to the base A C; and also that the same secant of E and cosecant of A (*i.e.* E A) is similarly proportioned to the hypotenuse A B as is the radius E F to the perpendicular B C.

By the same reasoning we may infer that the tangent of the angle B, or the cotangent of the angle A, holds the same relation to the base as the radius does to the perpendicular; for any of the preceding formulæ of proportionateness may be equated by inversion of their terms.

Proposition. *In any triangles, the sides are to one another as the sines of the opposite angles*—viz. A B : A C :: sin A : sin B.

Let A B C be any plane triangle—either acute (as fig. 4), or obtuse (as fig. 5). From each vertex let fall a perpendicular C D

Fig. 4.

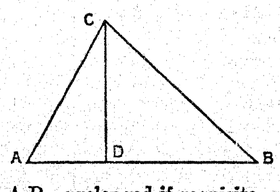
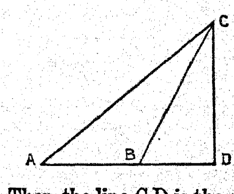


Fig. 5.

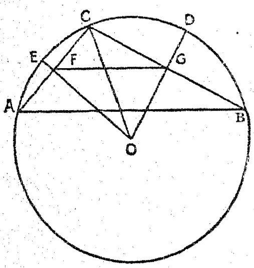


to A B—prolonged if requisite. Then the line C D is the sine of A to the radius A C; that is, C D $= \sin a$. Again, the line C D is the sine of angle B to the radius B C; that is, C D $= \sin b$. Equating these values they stand thus:—

$$a \sin B = b \sin A, \text{ and therefore } \frac{a}{b} = \frac{\sin A}{\sin B}$$

The same result may be very beautifully deduced geometrically in this way:—Any triangle can be inscribed in a circle. Let A B C (fig. 6) be the triangle given, and O be the centre of the circle. Draw the lines O D, O E, perpendicular to C B and C A, the sides of the triangle; then by Euclid III. 3 and 30, these sides of the triangle will be bisected, and so will the arcs which subtend these sides. Now an angle at the centre of a circle is double of an angle at the circumference when they both stand on the same arc (III. 20). Wherefore an angle at the centre is equal to an angle at the circumference standing on the double of the same arc, *i.e.* an angle at the circumference of a circle is measured by half the arc on which it stands, and an angle at the centre by the whole arc on which it stands. Hence C O D equals C A B, and C O E equals C B A. The sine of the angle C O D is C G, and C F is the sine of C O E. Join F G. It will be parallel to A B. Then, as is the case in all similar triangles, C G : C B :: C F : C A; that is, the sine of the angle at A is to the side C B as the sine of the angle at B is to the side C A, and *vice versa.*

Fig. 6.



When we know two sides of a triangle and an angle opposite to one of them, or two angles and a side opposite to one of them, the other three elements of the triangle may always be found in accordance with this proposition. The cosine of A (figs. 4 and 5) to the radius A C is A D, therefore $AD = b \cos A$; and the cosine of B to the radius B C is B D, therefore $BD = a \cos B$. Hence $c = a \cos B + b \cos A$. If instead of having the vertex at C, we took it at B, we should have for result $b = c \cos A + a \cos C$, and if A were taken as the vertex, the result would be $a = b \cos C + c \cos B$. These equations contain in brief the sum of plane trigonometry. They involve all the six parts of a triangle: (1) the three angles, (2) the three sides. These three equations enable us, any three parts being unknown quantities, to determine them, provided the other three (one being a side) are known; but fewer than three is insufficient. The method and the results of the transformation of these equations into others, and the logarithmic calculations into which they are transferable, will afford matter for further explanation.

HISTORY OF GREAT BRITAIN AND IRELAND.

CHAPTER III.

SAXON AND DANE — THE LOSS OF A KINGDOM — CANUTE'S CROWNING—PREPARING FOR GREAT CHANGES (941-1066).

EDMUND the Elder, surnamed the Deed-doer, the brother of Athelstan, who had been the "sure helper in war" of the hero of Brunanburgh, was, as the heir of Edward, chosen king. He was but eighteen, and his youth tempted the Danes to resist his domination. Under Anlaf, whom they called from Ireland, the Northumbrians revolted, and when Edmund entered the field against them, he found that, sanctioned by Wulfstan, archbishop of York, the Mercians also were up in arms. With strenuous heroism Edmund crossed the Humber, but the enemy was too powerful, and he, by treaty, resigned to Anlaf the district north of Watling Street —the great (*Gwaith-len*) legion-wrought Roman road which intersected the land. On Anlaf's death, his son could not maintain his power, and Edmund regained his lost rule in Northumbria. Over the Strathclyde Cumbrians, Edmund effected a conquest, but, knowing it would be hard to keep, and willing to subdue by conciliation a dangerous neighbour, "the King of the English" proffered his war-won land to Malcolm I., king of the Scots, to have and to hold as his own, provided the latter became the fellow-worker of the former by sea and land. Malcolm consented, and his dependency was secured. Thereafter Edmund turned his attention to the Danelaw, subdued Mercia, and reconquered from the Danes the five burghs—Leicester, Nottingham, Lincoln, Stamford, and Derby—which "were aforetime under the Northmen." During Edmund's reign, brief though it was, justice was carefully administered. In it, a law punishing robbery with death was passed. His first wife, Elgiva, was a most virtuous princess, who spent much of her fortune in purchasing the liberty of slaves. Turketel of Croyland, grandson of Alfred the Great, acted as chancellor of the kingdom, and faithfully fulfilled his duty to the king. Edmund met his death in his own house at Pucklechurch, by the dagger of an assassin—Leof, an outlaw—on St. Augustine's Day, 26th May, 946. Leof knew that, on a festival day, he could not be lawfully slain. On entering the hall the king's cup-bearer challenged him, and would have put him out. Edmund rose from his chair on the dais, caught Leof, drew him from his seat, and threw him on the floor. Leof thrust his knife into the king's heart. He died instantly, and was buried in Glastonbury Abbey, of which his friend Dunstan was abbot. Leof escaped.

The children of the warlike Edmund were too young to occupy the throne, and his brother Edred became his successor (946). He was crowned in the sight of the people in the open air, on a great platform raised in the market-place of Kingston-upon-Thames. There he received the homage of the Scots and the Cumbrians; but the Northumbrians under Eric (Blood-axe), son of Harold of the fair hair, king of Denmark, refusing to acknowledge his sovereignty, Edred, though feeble in health, resolved on their subjugation. A fierce struggle ensued, and Edred was victor. The Northumbrian rulers had been allowed to bear the royal name of king; but Edred degraded the territory to an earldom, setting over it a governor named Osulf; and conferred the northernmost part of the province, round Edinburgh, on the King of Scots, to be held by him as a fief. Edred took upon himself the style of "Sovereign of the fourfold empire of the Anglo-Saxons and Northumbrians, Pagans and Britons." Owing to the ambition of his nephews, Edred's rule was threatened with strife, but worn out with war and disease he died (955), and Edwin the Fair, son of Edmund I., was crowned with great magnificence at Kingston.

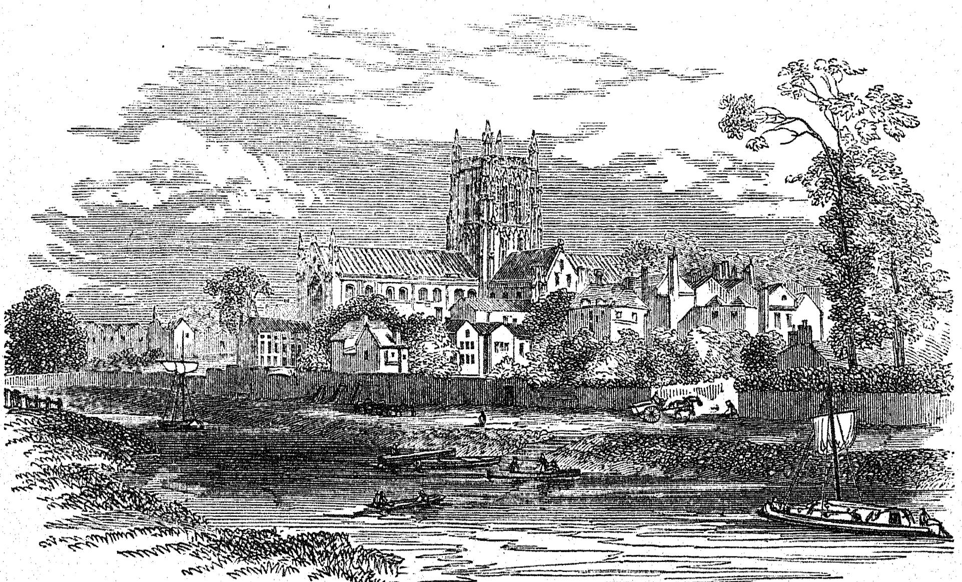
Turketel had by this time retired to Croyland, and Dunstan—nephew of Athelm, archbishop of Canterbury in Athelstan's reign—had become Edred's chief adviser and prime minister. Dunstan had created enemies among the churchmen by introducing the austere discipline of Benedict. The young king had been smitten by the charms of a handsome kinswoman of his own, named Elgiva, and had, in opposition to the advice—we might almost say the commands—of Dunstan and Odo, archbishop of Canterbury, married her secretly. On his coronation day, Edwin, misliking the rude merriment of the carouse, withdrew early from the festival, and sought the sweeter society of his spouse. The noisy nobles deputed Dunstan to recall the king to the banquet. Dunstan and Odo entered the royal apartment and beheld Edwin playfully caressing Elgiva. Applying to her the most opprobrious epithet that can be used to a woman, Dunstan dragged Edwin from her into the chamber of the carousal, to the great glee of the convivialists.

Of course, woman, monarch, and monk were soon embroiled. Edwin claimed account of Dunstan's administration of the royal finances. Dunstan refused, and the king, charging him with malversation, exiled the monk, who retired to St. Peter's at Ghent. The king took the part of the secular clergy, and the regulars, headed by Odo, who was a Dane, fomented revolt among his countrymen, and fanned ambition in the breast of the king's brother Edgar. A general rising took place in the Danish settlements, and the Witan of Mercia elected Edgar, who was advised to supplant his brother. Edwin divided the sovereignty with Edgar. The latter recalled Dunstan, and he, returning, brought with him the ban of the church upon Edwin's marriage as one within "the forbidden degrees" of cousinship. Elgiva's cheeks were branded to destroy their beauty. She was carried by force from the king's presence, and taken to Ireland. The glory of her loveliness was restored. She escaped from her durance in Erin, and having crossed the sea, was intercepted on her way to the king by Dunstan's orders, and imprisoned at Gloucester. Here she was tortured and ham-strung. Exposed at once to starvation and neglect, death soon put

a period to her sufferings. Meanwhile the revolt against the authority of Edwin grew more open and wide-spread, and at length he was deposed. Crownless, wifeless, without health of heart or strength of hope, he too was removed to Gloucester. Either by murder or from sorrow, while yet under twenty, he died.

Edgar was now, though still but a boy, sole monarch of the land. He had been trained under Odo, and the Danes had placed him on the throne. Dunstan was the despot who was really—*rex et regis imperator*—king and ruler of the king. He was bishop of Worcester and of London, and subsequently held simultaneously the sees of London and Rochester, as well as the primacy of Canterbury after Odo's demise. Edgar was an eager servant of the church. Gaining the throne when but a boy of fourteen, he exercised the functions of royalty fourteen years before he was formally crowned at Bath, "on the day of Pentecost," 973, by Dunstan and Oswald. The policy of Dunstan preserved the country from the pirates of the Baltic. Edgar's reign was not disturbed by foreign invasion or domestic discord. He was distinguished for public virtues and for private irregularities of life. He was a serf to the church and a slave to his passions. The church, the abbey, the cathedral pile bear witness of the former, and both the legends and the annals of his reign tell of the gay diplomacy by which he gratified the latter. Even Hume becomes poetic when he relates how Elfrida, daughter of Olgar, earl of Devonshire, became Edgar's second wife. The land was filled with praise of her beauty. The king's amorous nature was stirred. He commissioned Athelwold to inquire if rumour were right. He went, found that the half had not been told him, wooed, won, and wedded the lady. Returning, he reported that fame lied, but asked permission to wed her—for her wealth. Edgar consented, and then resolved to visit the bride. Athelwold besought her to conceal her loveliness; she resolved to blaze out in every form of fascination. Athelwold, while hunting with the king, was pierced by a javelin, and Elfrida became Edgar's queen.

In Edgar's reign, under Dunstan's rule, three fleets guarded the seashore of England; the Cambrians, the Scots, and the Cumbrians owned Edgar's overlordship; and, at his coronation, six sub-kings admitted vassalage and rowed him down the Dee to St. John's Minster. "God," said he, "has reduced under my power all that this island within it holds." He left



Worcester Cathedral.

two surviving children: Edward, son of his first wife Elflede, and Ethelred, son of his second wife Elfrida. The "Saxon Chronicle" records that "he loved foreign vices and brought heathen manners too fast within this land, and enticed hither outlandish men and allured pernicious people to this country," and notes that he departed this life 8th July, 975. It adds, "May God grant his good deeds be more prevailing than his misdeeds, for his soul's safety in the long journey."

Elfrida was anxious that her son Ethelred should be made king, but the chief aldermen chose Edward the son of Elflede. Ecclesiastical strife continued, and Elfrida fomented the commotions against Dunstan. The Danes, knowing that disputes were raging, seized the opportunity of renewing their incursions. Alfere of Mercia, and Oslac of Northumbria, resenting Dunstan's imperialism, and many of the clergy being opposed to his Benedictinism, the land was involved in sad contention. Nobles and ecclesiastics formed into parties, and Biornholm, a bishop of the old order, took charge of the strife against Dunstan in the church. Elfrida hoped for most from the anti-monastic party, and when—at a great meeting at Calne, at which it had been resolved to denounce Dunstan, an accident occurred which seemed to show that the monk was under the special protection of heaven—failure of that party became imminent, she bent her energy to defy fate. Edward, unweeting of danger, on some simple message visited his stepmother's house in a wood near Corfe. Elfrida invited him to alight, but he would not. She offered him a flagon of wine, and while he was drinking it, stabbed him in the back. He swooned, his horse gallopped off, dragging him by the rough stirrup-straps through the woodpath. He was found dead, and Elfrida had his body thrown into a ditch. The monks surnamed him "the Martyr."

A few of Dunstan's opponents met hastily and proclaimed Ethelred (978)—then only ten. Dunstan resolutely maintained his hostility to the king and his party. Since Athelstan's death, the shores of England had been free from the invader's foot; but now Anlaf of Norway, and Sweyn, the banished son of the sovereign of Denmark, brought their ship force to our shores. Southampton and Thanet were ravaged, Devon and West Wales had havoc wrought among them, and the pirates pillaged Portland and burned London. Sweyn's visits became systematic. In 991 they attacked East Anglia. The king was weak. His *unrede* (want of counsel) gained him the name of "the Unready." The nobles were not trustworthy. Treachery abounded, and ruin threatened the land. Ethelred was advised by Archbishop Sidric to bribe the Danes to depart. At a cost of £10,000, cowardice bought ease for court and camp. Year after year the shores were mercilessly harried. Though the Danegeld was levied, it failed to secure immunity from wrong and wretchedness. An animated poem tells us of the heroism of Brithnoth of Essex, who in 994, at Maldon, bravely resisted the marauding in-

vasion of Justin and Guthmund, and sped the death-spear against their hosts. In 997 unspeakable spoil was taken at Tavistock; by 1006 "they had sadly marked every shire in Wessex with fire and harrying." At last mismanagement produced chagrin, and "no shire would help another," although "everywhere they robbed and slew" the people. The Danes had proceeded so far gradually. The treacherous Elfric of Mercia had been banished, but Edric, his successor, walked in the same ways. Elfric was pardoned, and was placed in command of the fleet, but allowed himself to be defeated at sea. Edric, by subtle policy, more than once defeated the plans formed for the protection of the people. He counselled the king to enter into a treaty of friendship with Richard, duke of Rouen, and Ethelred took to wife Emma (Elgiva), that Norman noble's sister, who, though beautiful, was selfish and cold-hearted. Edric also advised the gravest crime and worst blunder of this wretched reign—the massacre of all the Danes in England on St. Brice's Day, 13th November, 1002. Among those thus slain was Gunhilda, Sweyn's sister, who had married a Saxon. After seeing her husband and her son struck down in her presence, she predicted that such acts would only exasperate her countrymen. Edric ordered her to be killed. On hearing of these atrocities, Sweyn swore that he would tear Ethelred from his throne, and set sail, for that purpose, with a large fleet. Thurkill the Tall followed with sixty ships full of soldiers, and sixteen shires were subjected. Ethelred fled to Normandy, and the English swore allegiance to Sweyn. Sweyn died shortly afterwards. Ethelred returned, promising "to rule rightlier than before," and every Dane was outlawed. But the Danish army chose Canute, Sweyn's son, as their king, and he claimed England as his father's conquest. He soon acquired the greater part of the land, and but for the brave Edmund (Ironside), Ethelred's son, would speedily have vanquished the whole isle. In April, 1016, Ethelred's inglorious reign came to an end. On his death Edmund was proclaimed his successor, but Canute had secured the fealty of many. Edmund fought six battles in seven months. Edric again played the traitor at Assingdon, and brought about his defeat. Canute agreed to divide the sovereignty with him. Edmund received Wessex; Canute took Mercia and the north. Edric of Mercia assassinated him on St. Andrew's Day, and Canute the Dane was, in 1017, king of all England.

The form of election by the Witanagemote was gone through according to custom, and the entire sovereignty of England was conferred by vote on Canute at the age of twenty. He at once outlawed all the descendants of Ethelred. Edmund's brother was murdered, and the children of that king were exiled to Sweden. Anlaf conveyed them to Hungary, where Stephen the Pious treated them honourably. The elder son, Edmund the Outlaw, married Agatha, daughter of the Emperor Henry II., and through Edgar Atheling and Margaret, queen of Scotland, transmitted the sovereign rights of the house of Cerdic. Canute divided England into four provinces, and for a time ruled it—as conquerors are said to be compelled to do—with a rod of iron. Finding that his crown was safe, Canute embraced Christianity, resolved to govern as an English king, restored the Witan, married Emma, Ethelred's widow, and paid off his Danish troops. Canute became the organizer of England, and made himself a famous name as a friend of peace, order, and civilization. Round himself he retained the crews of forty ships to act as a body-guard. They were called the king's house-earls, and were the first royal standing army in England. As most of the nobility had perished during the disastrous wars of Ethelred's reign, and he had conquered the country, Canute looked upon the territory as his own, and distributed it by writ to thanes, bishops, and reeves as he chose—thus abolishing the old notion of folkland among his subjects. By the institution of the four great provincial earldoms of Wessex, Mercia, East Anglia, and Northumbria, and by encouraging the jurisdiction of the nobility within their own territories, he relieved himself of many minor details in the management of the nation, and made the habits of the people more favourable to feudalism.

On the demise of his brother Harold (1019), Canute visited Denmark, and assumed the sovereignty of it. He reduced the Swedes and the Wends in Northern Germany in 1025. In 1027 he visited Rome, and wrote thence a letter to his British subjects, assuring them that he "had vowed to Almighty God to rule his life by righteousness, and his kingdom and people with equity—piously observing equal justice everywhere," and promising, if in youth he had done anything amiss, he would endeavour hereafter, by divine help, to amend it. He revisited Denmark and acquired the crown of Norway in 1028. He accepted homage from Malcolm II. of Scotland for Cumberland, and received, the chroniclers say, into submission Melbethe (Macbeth ?) and Jewart, two Scottish chiefs. On his return he engaged in many good works, constructed a causeway, "king's delf," from Peterborough to Ramsay, drained the Fens, built towers, bridges, and churches. He was fond of money, but spent it wisely, and greedy of power, which he used discreetly. He was shrewd, pious, and pleasant of speech; fond of hunting, poetry, and music; small, though lithe of frame, and active both in mind and body. He was not made haughty by power, nor corrupted by prosperity. Canute died, 1035, at Shaftesbury, and was sepulchred in Winchester.

Contrary to his promise to the English, that his children by Emma should succeed him, Canute bequeathed the crown of England to Harold and that of Norway to Sweyn—two sons of his older than Emma's son Hardicanute, whom he made king of Denmark. Egelnoth, archbishop of Canterbury, refused to place the crown on Harold's head, but laid it on the altar, saying, "I will neither give it to thee, nor prevent thy taking it, but I will not bless thee nor shall any bishop hallow thee on the throne." Harold ceded Wessex to Hardicanute, who, however, remained so long in his kingdom of Denmark that the thanes accepted Harold as sole sovereign, and banished Emma. Edward, her son, had sailed to Southampton, but finding the people indifferent to his claims returned to Normandy. Alfred, having been invited to visit his mother, was seized, imprisoned, and blinded at Ely, where he died. Hardicanute joined his mother at Bruges. He was preparing a fleet to assert his rights when news of Harold's death reached him, and he was, without opposition, acknowledged as king. He invited Edward to court and put Earl Godwin on trial for the murder of Alfred. The chief thanes acquitted Godwin, and the monarch received him into favour. To show his despite of his predecessor, Hardicanute had Harold's body exhumed and cast into a fen. The heavy taxes he levied made him unpopular. He was a belier of his pledged faith by betraying Eadulf, earl of Northumberland, who had placed himself under his protection. Insurrections arose, and he laid Worcester waste. On the 8th of June, at the marriage of the daughter of Osgod Clapa, his high steward, to the Danish chief Tawid the Proud, his standard-bearer, he was standing up to pledge the health of the wedded pair when he fell suddenly, in terrible convulsions, and without speaking died. He was buried in the old minster of Winchester, and, for his soul's sake, his mother gifted to the new minster the head of St. Valentine the Martyr.

Edward the Confessor was immediately chosen king, though Edward the Outlaw was still alive. He was remarkable for munificence and piety, but he was a foreigner in habits, interest, and speech. He gained a transient popularity by banishing many of the most eminent Danes. He married Edgitha, Godwin's daughter, to win his aid; and though he was nominally sovereign, the son of Wulfnoth, "the Child of Sussex," really wielded the kingly power. Godwin resented French influences—the Witan exiled him. He went to Flanders, whence he soon returned with a great fleet and threatened to invade the land. Edward conceded all he asked, and the Godwin family regained their domination over him. William of Normandy visited Edward in 1051. In 1054 Edward espoused the cause of Malcolm against Macbeth, and sent Siward of Northumbria to defend the right. Harold, Edgitha's brother, succeeded his father as Earl of Wessex, and he and Tostig subdued the Cambrians and defeated Prince Griffiths. Edward recalled from Hungary Edward, son of Edmund Ironside, and his son Edgar the Etheling; the former died in a short time, and left the latter the sole living representative of the early Saxon line. Harold

actively undertook all warlike expeditions and all embassies and political affairs. The king devoted himself to church-building, holy contemplation, and pious deeds. At Christmas he was present at the consecration of Westminster Abbey, and on Twelfth Night, 1066, "then, suddenly, came Death the bitter, and that dear Prince took from the earth. The angels bore his soothfast soul into Heaven's light. But the wise king bestowed the realm on one grown great, on Harold's self—a noble earl." Next day Edward the Confessor was laid to rest "within the newly hallowed church of St. Peter's, and Harold, for three months, was *king*."

THE GREEK LANGUAGE.—CHAPTER III.

ADJECTIVES—DECLENSION AND COMPARISON—IRREGULAR FORMATIONS.

ADJECTIVES express the qualities or attributes of things.

Adjectives in their declension follow the forms and inflexions of nouns. In adjectives of three forms, *i.e.* one for each gender, the feminine is declined like nouns of the First Declension, and the masculine and neuter like those of the Second or Third, according to their respective terminations.

Adjectives having the masc. in		make the fem. in		and the neut. in
	ος		η	ον
	υς		εια	υ
	εις		εσσα	εν
	ους		η	ουν
	ας		ασα	αν
	ος*		α	ον

* Preceded by a vowel or ρ, as ἁγι-ος, -α, -ον; ἀνθηρ ος, -α, -ον.

EXAMPLES.—Αγανος, -η, -ον, mild; ἀμβλυς, -εια, -υ, dull, blunt; ὑληεις, -εσσα, -εν, woody; ἁπλους, -η, -ουν, simple; πας, -ασα, -αν, every, all.

Adjectives are either (1) of the First and Second Declension, (2) of the Second only, (3) of the First and Third, or (4) of the Third only.

1. ADJECTIVES OF THE FIRST AND SECOND DECLENSION.

These have their masculine in ος, their feminine in η or α, and their neuter in ον. Most adjectives in ιος and ρος are declined with *three* terminations.

Those in ος pure and ρος have α in the feminine; all others in ος, including those in οος not preceded by ρ, have η.

μονος, alone.

Singular.

	Masc.	Fem.	Neut.
Nom.,	μονος,	μονη,	μονον·
Gen.,	μονου,	μονης,	μονου·
Dat.,	μονῳ,	μονῃ,	μονῳ·
Acc.,	μονον,	μονην,	μονον·
Voc.,	μονε,	μονη,	μονον·
Dual.			
N. A. V.,	μονω,	μονα,	μονω·
G. D.,	μονοιν,	μοναιν,	μονοιν.
Plural.			
N. V.,	μονοι,	μοναι,	μονα.
Gen.,	μονων,	μονων,	μονων·
Dat.,	μονοις,	μοναις,	μονοις.
Acc.,	μονους,	μονας,	μονα·

Similarly decline, ἀγαθος, good; κακος, bad; μαλακος, soft; ἁπαλος, tender; λευκος, white; δηλος, evident; τερπνος, pleasant.

But those in (1) ος pure and (2) ρος are declined with α in the feminine, thus:—

Φιλιος, friendly.

Singular.

	Masc.	Fem.	Neut.
Nom.,	Φιλιος,	Φιλια,	Φιλιον.
Gen.,	Φιλιου,	Φιλιας,	Φιλιου.
Dat.,	Φιλιῳ,	Φιλιᾳ,	Φιλιῳ.
Acc.,	Φιλιον,	Φιλιαν,	Φιλιον.
Voc.,	Φιλιε,	Φιλια,	Φιλιον.

ἱερος, sacred.

Singular.

	Masc.	Fem.	Neut.
Nom.,	ἱερος,	ἱερα,	ἱερον·
Gen.,	ἱερε,	ἱερα,	ἱερον·
Dat.,	ἱερου,	ἱερας,	ἱερου·
Acc.,	ἱερῳ	ἱερᾳ.	ἱερῳ.
Voc.,	ἱερον,	ἱεραν,	ἱερον.

In the dual and plural the cases have all the endings like those of μονος.

Decline similarly, ἀξιος, worthy; μικρος, small; ἀργυρεος, silvery; μακρος, long; ἁγιος, holy; ἀγριος, rustic; πονηρος, wicked; πορφυρεος, purple; ὁμοιος, like; Φοβερος, terrible; ελευθερος, free.

Πολυς and μεγας form their cases regularly as from πολλος and μεγαλος, except in the nominative, accusative, and vocative, singular, masculine, and neuter.

πολυς, πολλη, πολυ, many.

Singular.

	Masc.	Fem.	Neut.
Nom.,	πολυς,	πολλη,	πολυ·
Gen.,	πολλου,	πολλης,	πολλου·
Dat.,	πολλω,	πολλῃ,	πολλῳ·
Acc.,	πολυν,	πολλην,	πολυ·
Voc.,	πολυ.	πολλη,	πολυ·

Dual and plural regularly formed from πολλ ς, πολλη, πολλον.

μεγας, μεγαλη, μεγα, great.

Singular.

	Masc.	Fem.	Neut.
Nom.,	μεγας,	μεγαλη,	μεγα·
Gen.,	μεγαλου	μεγαλης,	μεγαλου.
Dat.,	μεγαλῳ.	μεγαλῃ,	μεγαλῳ·
Acc.,	μεγαν,	μεγαλην,	μεγα·
Voc.,	μεγα,	μεγαλη,	μεγα·

Dual and plural regularly formed from μεγαλος, μεγαλη, μεγαλον.

2. ADJECTIVES OF THE SECOND DECLENSION.

These have their masculine and feminine in ος, and their neuter in ον. As some nouns in ος of the Second Declension are masculine and some feminine, so in some adjectives of this declension the form in ος serves for both masculine and feminine; as, masc. and fem. ἀλκιμος, powerful; neuter, ἀλκιμον; gen. for all genders, ἀλκιμου.

There are a few adjectives of this declension in ως. These have the neuter in ων; thus, ἱλεως, ἱλεων, propitious; ἀγηρως, ἀγηρων, unfading; and are declined like nouns of the Second Declension of the same termination; as, masc. and fem ἐμπλεως, full; neut. ἐμπλεων; gen. sing. (for all genders ἐμπλεω.

EXAMPLES IN ος, ος, ον.

κοσμιος, ος, ον, elegant.

Singular.

	Masc.	Fem.	Neut.
Nom.,	κοσμιος,	κοσμιος,	κοσμιον.
Gen.,	κοσμιου,	κοσμιου,	κοσμιου.
Dat.,	κοσμιῳ,	κοσμιῳ,	κοσμιῳ.
Acc.,	κοσμιον,	κοσμιον,	κοσμιον.
Voc.,	κοσμιε,	κοσμιε,	κοσμιον.
Dual.			
N. A. V.,	κοσμιω,	κοσμιω,	κοσμιω.
G. D.,	κοσμιοιν,	κοσμιοιν,	κοσμιοιν.
Plural.			
N. V.,	κοσμιοι,	κοσμιοι,	κοσμια.
Gen.,	κοσμιων,	κοσμιων.	κοσμιων.
Dat.,	κοσμιοις.	κοσμιοις,	κοσμιοις.
Acc.,	κοσμιους,	κοσμιους,	κοσμια.

So decline οὐρανιος, ος, ον, heavenly; πολυφαγος, ος, ον, voracious; ἐνδοξος, ἐνδοξον, renowned; ἀδικος, unjust; ἀδυνατος, unable; εὐφωνος, harmonious; παγκαλος, quite beautiful; ἀγαμος, unmarried, &c.

The contractions of adjectives agree exactly with the rules given in regard to the declensions of nouns; as, ἁπλοος, οη, οον, single; ἀθροος, ἀθροα, ον, crowded; διπλοος, οη, οον, contracted διπλους, η, ουν, double (and all *multiple* numerals); πορφυρεος, ρεα, ρεον, contracted πορφυρους, ρα, ρουν, purple.

	Singular. Masc.	Fem.	Neut.	*Singular.* Masc.	Fem.	Neut.
N.	διπλους,	διπλη,	διπλουν;	πορφυρους,	πορφυρα,	πορφυρουν.
G.	διπλου,	διπλης,	διπλου;	πορφυρου,	πορφυρας,	πορφυρου.
D.	διπλῳ,	διπλῃ,	διπλῳ;	πορφυρῳ,	πορφυρᾳ,	πορφυρῳ.
A.	διπλουν,	διπλην,	διπλουν;	πορφυρουν,	πορφυραν,	πορφυρουν.
V.	διπλου,	διπλη,	διπλουν;	πορφυρεε,	πορφυρα,	πορφυρουν.

Dual.	Masc.	Fem.	Neut.
N. A. V.,	διπλω,	διπλα,	διπλα.
G. D.,	διπλοιν,	διπλαιν.	διπλοιν.
Plural.			
N. V.,	διπλοι,	διπλαι,	διπλα
Gen.,	διπλων,	διπλων,	διπλων.
Dat.,	διπλοις,	διπλαις,	διπλοις.
Acc.,	διπλους,	διπλας,	διπλα.

The case-endings of πορφυρους in the plural are exactly similar to those of διπλους.

Compounds of πους ποδος, a foot, take the inflection of the noun—*e.g.* διπους, διπους, διπουν; διποδος, διποδι, διποδα.

3. Adjectives of the First and Third Declension.

Adjectives of the First and Third Declension have their feminine in α of the First, and their masculine and neuter of the Third. Their terminations are—

Nominative. Masc.	Fem.	Neut.	*Genitive.* Masc.	Fem.	Neut.	*Voc.* Masc.
-ας,	αινα,	αν.	-ανος,	αινης.	ανος.	-αν.
-ην,	εινα,	εν.	ενος,	εινης,	ενος.	-εν.
-ιεις,	ιεσσα.	ιεν.	-ιεντος,	ιεσσης.	ιεντος.	-εν.
-οεις.	οεσσα,	οεν.	-ουντος,	ουσσης,	ουντος.	-ου.
-ους	ουσσα,	ουν.				
-ηεις,	ηεσσα,	ηεν.	ηντος,	ησσης,	ηντος.	-εν.
-ης,	ισσα,	ην.				
-υς,	εια,	υ.	-εος,	ειας,	εος.	-υ.
-ω,	ουσα.	ον.	-οντος,	ουσης,	οντος.	-αν.
-ας,	ασα,	αν.	-αντος,	ασης,	αντος.	-ων.
-εις,	εισα,	εν.	-εντος.	εισης,	εντος.	-εν.

μελας, μελαινα, μελαν, black.

Singular.	Masc.	Fem.	Neut.
Nom.,	μελας,	μελαινα,	μελαν.
Gen.,	μελανος,	μελαινης,	μελανος.
Dat.,	μελανι,	μελαινῃ,	μελανι.
Acc.,	μελανα,	μελαιναν,	μελαν.
Voc.,	μελαν,	μελαινα,	μελαν.
Dual.			
N. A. V.,	μελανε,	μελαινα.	μελανε.
G. D.,	μελανοιν,	μελαιναιν,	μελανοιν.
Plural.			
N. V.,	μελανες,	μελαιναι,	μελανα.
Gen.,	μελανων,	μελαινων,	μελανων.
Dat.,	μελασι (ν),	μελαιναις,	μελασι (ν).
Acc.	μελανας,	μελαινας,	μελανα.

Similarly decline the only like adjective ταλας, miserable.

χαριεις, χαριεσσα, χαριεν, graceful.

Singular.	Masc.	Fem.	Neut.
Nom.,	χαριεις,	χαριεσσα,	χαριεν.
Gen.,	χαριεντος,	χαριεσσης,	χαριεντος.
Dat.,	χαριεντι,	χαριεσσῃ,	χαριεντι.
Acc.	χαριεντα,	χαριεσσαν,	χαριεν.
Voc.	χαριεν,	χαριεσσα,	χαριεν.
Dual.			
N. A. V.,	χαριεντε,	χαριεσσα.	χαριεντε
G. D.,	χαριεντοιν	χαριεσσαιν.	χαριεντοιν.
Plural.			
N. V.,	χαριεντες.	χαριεσσαι	χαριεντα.
Gen.,	χαριεντων,	χαριεσσων	χαριεντων.
Dat.,	χαριεσι (ν).	χαριεσσαις,	χαριεσι (ν).
Acc.,	χαριεντας.	χαριεσσας,	χαριεντα.

Similarly decline τιμηεις, honoured; ανεμοεις, windy; ἠχηεις, loud sounding; αἱματοεις, bloody; μελιτοει, sweet.

βαρυς, βαρεια, βαρυ, heavy.

Singular.	Masc.	Fem.	Neut.
Nom.,	βαρυς,	βαρεια.	βαρυ.
Gen.,	βαρεος,	βαρειας,	βαρεος.
Dat.,	βαρει,	βαρειᾳ,	βαρει.
Acc.,	βαρυν,	βαρειαν,	βαρυ.
Voc.,	βαρυ,	βαρεια,	βαρυ.
Dual.			
N. A. V.,	βαρεε,	βαρεια,	βαρεε.
G. D.,	βαρεοιν,	βαρειαιν,	βαρεοιν.
Plural.			
N. V.,	βαρεες,	βαρειαι,	βαρεα
Gen.,	βαρεων.	βαρειων	βαρεων.
Dat.,	βαρεσι,	βαρειαις,	βαρεσι.
Acc.,	βαρεας,	βαρειας.	βαρεα.

Similarly decline βαθυς, deep; βραδυς, slow; γλυκυς, sweet; ἡδυς, pleasant; ἡμισυς, the half.

Adjectives in υς, εια, υ are contracted in dative singular and nominative and vocative plural, but the neuter plural is seldom if ever contracted.

πας, πασα, παν, every, all.

Singular.	Masc.	Fem.	Neut.
N. V.,	πας,	πασα,	παν.
Gen.,	παντος.	πασης,	παντος.
Dat.,	παντι.	πασῃ,	παντι.
Acc.	παντα.	πασαν,	παν.
Dual.			
N. A. V.,	παντε,	πασα.	παντε.
G. D.	παντοιν.	πασαιν,	παντοιν.
Plural.			
N. V.,	παντες.	πασαι,	παντα.
Gen.,	παντων.	πασων,	παντων.
Dat.,	πασι,	πασαις,	πασι.
Acc.,	παντας,	πασας.	παντα.

So decline ἁπας, the whole entirely, and συμπας, all in a body, and all participles in ας, ασα, αν; as στας, στασα σταν, standing.

ἑκων, ἑκουσα, ἑκον, willing.

Singular.	Masc.	Fem.	Neut.
N. V.,	ἑκων,	ἑκουσα,	ἑκον.
Gen.,	ἑκοντος,	ἑκουσης,	ἑκοντος.
Dat.,	ἑκοντι,	ἑκουσῃ,	ἑκοντι.
Acc.,	ἑκοντα,	ἑκουσαν,	ἑκον.
Dual.			
N. A.,	ἑκοντε,	ἑκουσα,	ἑκοντε.
G. D.,	ἑκοντοιν,	ἑκουσαιν,	ἑκοντοιν.
Plural.			
N. V.,	ἑκοντες,	ἑκουσαι,	ἑκοντα.
Gen.,	ἑκοντων,	ἑκουσων,	ἑκοντων.
Dat.,	ἑκουσι,	ἑκουσαις,	ἑκουσι.
Acc.	ἑκοντας,	ἑκουσας,	ἑκοντα.

Similarly decline ἀκων, unwilling; and participles in ων, ουσα, ον, and ους, ουσα, ουν; as τυπτων, striking; τυψων, about to strike; διδους, giving; δους, having given.

4. Adjectives of the Third Declension.

These have their masculine and feminine alike.

Examples in ης, ης, ες; ἀληθης, ἀληθης, ἀληθες, true.

Singular.

	Masc.	Fem.	Neut.
Nom.,	ἀληθης,	ἀληθης,	ἀληθες.
Gen.,	ἀληθεος,	ἀληθεος,	ἀληθεος, c. -ους.
Dat.,	ἀληθει,	ἀληθει,	ἀληθει,
Acc.,	ἀληθεα,	ἀληθεα, c. -η,	ἀληθες.
Voc.,	ἀληθες.	ἀληθες,	ἀληθες.

Dual.

N. A. V.,	ἀληθεε,	ἀληθεε,	ἀληθεε, c. -η.
G. D.,	ἀληθεοιν,	ἀληθεοιν,	ἀληθεοιν -οιν.

Plural.

N. V.,	ἀληθεες,	ἀληθεες, c. εις,	ἀληθεα -η.
Gen.,	ἀληθεων,	ἀληθεων,	ἀληθεων -ων.
Dat.,	ἀληθεσι (ν),	ἀληθεσι (ν),	ἀληθεσι (ν).
Acc.,	ἀληθεας,	ἀληθεας -εις,	ἀληθεα -η.

Similarly decline εὐγενης, noble; ἀκριβης, exact; εὐπρεπης, decorous; εὐκλεης, glorious.

ἰδρις, ἰδρις, ἰδρι, skilful.

Singular.

	Masc.	Fem.	Neut.
Nom.,	ἰδρις,	ἰδρις,	ἰδρι.
Gen.,	ἰδριος,	ἰδριος,	ἰδριος.
Dat.,	ἰδριι.	ἰδριι,	ἰδριι, c. ἰδρι.
Acc.,	ἰδριν,	ἰδριν,	ἰδρι.
Voc.,	ἰδρι,	ἰδρι,	ἰδρι.

Dual.

N. A. V.,	ἰδριε,	ἰδριε,	ἰδριε.
G. D.,	ἰδριοιν,	ἰδριοιν.	ἰδριοιν.

Plural.

N. V.,	ἰδριες,	ἰδριες, c. -ις,	ἰδρια.
Gen.,	ἰδριων,	ἰδριων,	ἰδριων.
Dat.,	ἰδρισι (ν),	ἰδρισι (ν),	ἰδρισι (ν).
Acc.,	ἰδριας,	ἰδριας, -ις,	ἰδρια.

Similarly decline εὐχαρις, gen. -ιτος, acc. masc. and fem. -ιτα or -ιν, voc. -ι, pleasant; Φιλοπατρις, gen. -ιδος, acc. masc. and fem. -ιδα or -ιν, voc. -ι, patriotic; and adjectives in υς, υς, υ; as συνοφρυς, -υς, -υ, gen. -υος, supercilious; ἀδακρυς, -υς, -υ, unpitied.

σωφρων, σωφρων, σωφρον, prudent.

Singular.

	Masc.	Fem.	Neut.
Nom.,	σωφρων,	σωφρων,	σωφρον.
Gen.,	σωφρονος,	σωφρονος,	σωφρονος.
Dat.,	σωφρονι,	σωφρονι,	σωφρονι.
Acc.,	σωφρονα	σωφρονα,	σωφρον.
Voc.,	σωφρον,	σωφρον,	σωφρον.

Dual.

N. A. V.,	σωφρονε,	σωφρονε,	σωφρονε.
G. D.,	σωφρονοιν,	σωφρονοιν.	σωφρονοιν.

Plural.

N. V.,	σωφρονες,	σωφρονες,	σωφρονα.
Gen.,	σωφρονων,	σωφρονων,	σωφρονων.
Dat.,	σωφροσι (ν),	σωφροσι (ν),	σωφροσι (ν).
Acc.,	σωφρονας,	σωφρονας,	σωφρονα.

Similarly decline ἐλεημων, compassionate; ἀμυμων, blameless; εὐδαιμων, fortunate; ἀῤῥην or ἀρσην, genitive ἀῤῥενος or ἀρσενος, manly; also comparatives in ων; as μειζων, greater; βελτιων, better.

διπους, διπους, διπουν, two-footed.

Singular.

	Masc.	Fem.	Neut.
Nom.,	διπους,	διπους,	διπουν.
Gen.,	διποδος,	διποδος,	διποδος.
Dat.,	διποδι,	διποδι,	διποδι.
Acc.,	διποδα or -ουν,	διποδα or -ουν,	διπουν.
Voc.,	διπους or -ου,	διπους or -ου,	διπουν.

Dual.

	Masc.	Fem.	Neut.
N. A. V.,	διποδε,	διποδε.	διποδε.
G. D.,	διποδοιν.	διποδοιν,	διποδοιν.

Plural.

N. V.,	διποδες,	διποδες.	διποδα.
Gen.,	διποδων,	διποδων,	διποδων.
Dat.,	διποσι (ν).	διποσι (ν),	διποσι (ν).
Acc.,	διποδας.	διποδας,	διποδα.

Similarly decline βοαδυπους, slow-footed; ὑψιπους, sublime; δεινοπους, terrible.

Comparison of Adjectives.

The degrees of comparison are three: (1) *positive*, (2) *comparative*, and (3) *superlative*.

The most common form of indicating comparison is by adding τερος, α, ον for the comparative, and τατος, η, ον for the superlative; as positive, μακαρ, blessed; comparative, μακαρτερος; superlative, μακαρτατος.

A less common method of indicating the comparison of adjectives is by adding ιων to form the comparative and ιστος to denote the superlative; as

Pos.		Comp.	Super.
ἡδυς,	sweet,	ἡδιων,	ἡδιστος.
αἰσχρος,	ugly,	αἰσχιων,	αἰσχιστος.
καλος,	beautiful,	καλλιων,	καλλιστος.

(In the last the final λ of the stem is doubled.)

This form is adopted with some adjectives in ρος (omitting ρ), and by some in υς; as

Pos.		Comp.	Super.
αἰσχρος,	base,	αἰσχιων,	αἰσχιστος.
ἐχθρος,	hostile,	ἐχθιων,	ἐχθιστος.
κυδρος,	glorious,	κυδιων,	κυδιστος.
μακρος,	long,	μασσων.	μηκιστος.
οἰκτρος,	sad,	—	οἰκτιστος.
βαθυς,	deep,	βαθιων, βασσων,	βαθιστος.
παχυς,	fat,	παχιων, πασσων,	παχιστος.
ταχυς,	swift,	ταχιων, θασσων,	ταχιστος.
βραχυς,	short,	βρασσων,	βραχιστος.
ἠλαχυς,	small,	ἐλασσων,	ἐλαχιστος.

This mode of comparison occurs principally with adjectives in υς, but many even of these have also the other terminations, τερος and τατος.

Comparatives in ων sometimes drop ν from ονα, ονες, and ονας, and then contract οα into ω, οες and οας into ους. Thus μειζονα becomes μειζω; μειζονες or μειζονας becomes μειζους.

Adjectives whose positives end in ος or υς reject the ς before τερος, τατος, the ο being changed into ω, if the preceding syllable is short, but they retain ο unchanged if a long syllable precede; as πιστος, faithful, πιστοτερος, πιστοτατος.

ος preceded by a doubtful vowel admits of either ο or ω; as ἰσος, equal, ἰσοτερος, ἰσοτατος, or ἰσωτερος ἰσωτατος.

Adjectives in ης and εις change these terminations into ες before τερος and τατος in the comparative and superlative; as χαριεις, graceful, χαριεστερος, χαριεστατος.

Positive adjectives ending in ας, ης, and υς add τερος and τατος to the nominative singular neuter, ων to the nominative plural masculine; as

Pos.	Pos.	Comp.	Super.
μελας, black,	N. μελαν,	μελαντερος,	μελαντατος.
εὐσεβης, pious,	εὐσεβες,	εὐσεβεστερος,	εὐσεβεστατος.
εὐρυς, broad,	εὐρυ,	εὐρυτερος,	εὐρυτατος.
ἀφρων, senseless,	N.P. ἀφρονες,	ἀφρονεστερος,	ἀφρονεστατος.

All other adjectives that take τερος connect it with the root by the syllable ες, sometimes ις.

The original terms denoting comparison appear to have been εστερος and εστατος, shortened in most instances into τερος and τατος. Especially in the Attic dialect comparison is made from adjectives in ος by adding εστερος, εστατος; also ιστερος, ιστατος, and αιτερος, αιτατος; as—

Pos.		Comp.	Super.
ἀφθονος,	abundant,	ἀφθονεστερος,	ἀφθονεστατος.
ἀκρατος,	unmixt,	ἀκρατεστερος,	ἀκρατεστατος.
λαλος,	loquacious,	λαλιστερος,	λαλιστατος.
ψευδης,	false,	ψευδιστερος,	ψευδιστατος.
φιλος,	friendly,	φιλαιτερος, φιλτερος,	φιλαιτατος. φιλτατος and φιλιστος.
πλησιος,	near,	πλησιαιτερος,	πλησιαιτατος.

So some in αιος are formed by αιτερο and αιτατος; as

παλαιος,	ancient,	παλαιτερος,	παλαιτατος.
γεραιος,	old,	γεραιτερος,	γεραιτατος.

And some in ης are thus compared—

ὑβριστης,	insolent,	ὑβριστοτερος,	ὑβριστοτατος.
πλεονεκτης,	covetous,	—	πλεονεκτιστατος.

The following list contains those irregular comparatives and superlatives which most frequently occur:—

Pos.		Comp.	Super.
ἀγαθος,	good,	ἀμεινων, N. ἀμεινον,	ἀριστος.
		ἀγειων,	ἀγαθωτατος.
		βελτιων,	βελτιστος.
		βελτερος,	βελτατος.
		κρεισσων,	κρατιστος.
		λωιων,	λωιστος,
κακος,	bad,	κακιων,	κακιστος.
		ἡσσων or ἡττων,	ἡκιστος.
μακρος,	long,	μακροτερος,	μακροτατος.
		μηκιων or μησσων,	μηκιστος.
μικρος,	small,	μικροτερος,	μικροτατος.
		ἐλασσων	ἐλαχιστος.
πολυς,	much,	πλειων or πλεων,	πλειστος.
ῥᾳδιος,	easy,	ῥᾳων,	ῥᾳστος.
μεγας,	great,	μειζων,	μεγιστος.

Comparatives and superlatives are also formed from nouns, pronouns, verbs, adverbs, prepositions, and participles; as

1. FROM NOUNS.

		Comp.	Super.
κερδος,	gain,	κερδιων, more covetous,	-ιστος.
ῥιγος,	horror,	ῥιγιων, more dreadful,	-ιστος.

2. FROM ADVERBS.

ἀνω,	upwards,	ἀνωτερος,	-τατος.
κατω,	beneath,	κατωτερος.	-τατος.

3. FROM PREPOSITIONS.

ὑπερ, above, ὑπερτερος, ὑπερτατος, by syncope ὑπατος.

προ, before, προτερος, former, προτατος, first; by a syncope πρατος, by contraction πρωτος, and by doubling the superlative πρωτιστος, by far the first.

ADJECTIVES OF TWO TERMINATIONS.

These have two forms—one for the masculine and feminine in common and one for the neuter—and end in

M. & F.	N.				
ης,	ες,	as	ἀληθης,	ες,	true.
ις,	ι,		εὐχαρις,	ι,	graceful.
υς,	υ,		ἀδακρυς,	υ,	tearless.
ους,	ουν,		πολυπους,	ουν,	many-footed.
ην,	εν,		τερην,	εν,	tender.
ος,	ον,		ἀθανατος,	ον,	immortal.
ων,	ον,		εὐδαιμων,	ον,	fortunate.
ως,	ων,		εὐγεως,	ων,	fertile.

The inflexions in the neuter are the same as in the masculine and feminine, except that the nominative, accusative, and vocative cases are alike in both numbers, and in the plural these cases end in α.

Those ending in ων, ην, ης form their neuter by changing the long into the short vowel; thus—σωφρων, σωφρον, prudent; ἀρσην, ἀρσεν, male; ἀληθης, ἀληθες, true.

Compounds of πους, a foot, have the neuter in ουν; as διπους, διπουν, two-footed; and those in ις and υς form the neuter by rejecting ς; as εὐχαρις, εὐχαρι, gracious.

The following adjectives may be regarded as irregular. They want the neuter gender; thus—ἁρπαξ, G. ἁρπαγος, rapacious; ἀπαις, G. ἀπαιδος, childless; μακαρ, G. μακαρος, happy; ἀγνως, G. ἀγνωτος, unknown.

Some adjectives in ης and ας are masculine only, and are declined like nouns of the First Declension; as ὑβριστης, insolent; πλεονεκτης, covetous. Γερων, οντος, old; and πενης, ητος, poor, are of the Third, and are only used as masculine.

Some adjectives in ας are masculine and feminine, and of the Third Declension; as φυγας, αδος, fugitive; νομας, αδος, erratic; also some in ις and υς.

ADJECTIVES OF ONE TERMINATION.

Adjectives of one termination, with the exception of the indeclinable numerals from πεντε, five, to ἑκατον, a hundred, want the neuter gender; as μακαρ, μακαρος, happy; ἀπαις, ἀπαιδος, childless. Those in ας, αδος and ις, ιδος are for the most part feminine only, and are often declined as nouns.

The numerals are in reality adjectives. The two principal classes are the cardinals and the ordinals. The first four cardinals are declinable, but from 5 to 100 they are all indeclinable. The ordinals, however, are regular adjectives of three forms.

	(1) one.	(2) two.	(3) three.	(4) four.
N.	εἱς, μια, ἑν,	δυο and δυω,	τρεις, τρια,	τεσσαρες, -αρα.
G.	ἑνος, μιας, ἑνος,	δυοιν [δυειν, Att.]	τριων,	τεσσαρων.
D.	ἑνι, μια, ἑνι,	δυοιν (δυσι),	τρισι,	τεσσαρσι.
A.	ἑνα, μιαν, ἑν,	δυο,	τρεις, τρια,	τεσσαρες, -αρα.

The compounds of εἱς—μηδεις, and οὐδεις, no one—are declinable like εἱς.

1. Cardinal numerals express a definite number, and answer the question, "How many?" as εἱς, one; δυο, two; τρεις, three, &c.

2. Ordinal numerals denote numbers in succession, and answer the question, "Which special one of a number?" as πρωτος, the first; δευτερος, the second; τριτος, the third, &c.

3. Distributives refer to numbers taken apart; as ἑκαστος, each; συνδυο, two by two.

4. Multiplicatives indicate that the operation of multiplication is to be thought of in connection with them; as ἁπλους, simple; διπλους, double; τριπλους, triple, &c.

5. Proportionals denote that relations and parts are to be considered; as διπλασιος, twice as many; τριπλασιος, thrice as many; πολυπλασιος, many times, &c.

6. Abstract numerals refer to number in itself, and not as existing in concrete things; as μονας, αδος, unity; δυας, τριας, τετρας, πεμπτας, ἑξας, ἑβδομας, &c.

7. Adverbials introduce numerical references into sentences; as ἁπαξ, once; δις, twice; τρις, thrice; τετρακις, four times; πεντακις, five times, &c.

Among the numerals we might class several adjectives; as ἑκαστος, each; ἑκατερος, each of the two; πας, all; as well as several adverbs; as πολλακις, often; πλειστακις, very often; ὀλιγακις, seldom; μονοχῃ, singly; διχῃ and διχα, twofold, apart; τριχῃ, τετραχῃ, πολλαχῃ; πανταχῃ, everywhere; διπλῃ, doubly; τριπλῃ, trebly, &c.

From the feminine ordinals a secondary ordinal is formed, denoting the day on which an event happened; as δευτεραιος ἠλθε, he came on the second day; τριταιος ἀπεθανεν, he died on the third day.

EXERCISES.

Decline together, through all their cases and numbers, the following adjectives and substantives:—

(1) Having their terminations in ος, η, ον, or in ος pure and ρος; ἀνθρωπος ἀξιος, a worthy man; ἀφθονον χρημα, immense wealth; ἀθλια γυνη, an unhappy woman; Αδωνις δυσποτμος, unfortunate Adonis; δεξια χειρ, the right hand; ἐθνος ἰσχυρος, a powerful nation; νεανιας καλος, a handsome youth; στενη ὁδος, a narrow road; δεσμος ἀργαλεος, a cruel chain; νεογαμη γυνη, a newly married wife; καλη ἠως, beautiful morning.

(2) Having the terminations ας, αινα, αν; εις, εσσα, εν; υς, εια, υ; as πτεροεν ἐπος, a winged word; μελαν ἱματιον, a black garment; πολεμος θρασυς, furious war; παγος ὀξυς, a sharp cliff; ἡδεια ἀοιδη, sweet song; νυξ μελαινα, dark night.

ENGLISH LITERATURE.—CHAPTER V.

THE EARLY POETS OF SCOTLAND—WYNTOUN—BLIND HARRY—KING JAMES I.—HENRYSON—DUNBAR—KENNEDY—GAWIN DOUGLAS—SIR DAVID LINDSAY—MINOR POETS.

CHAUCER's courtly portly figure stands strangely isolated among English poets. From his death in 1400 till Spenser's birth in 1552—upwards of a century and a half—no poet of genius worthy of being regarded as his successor arose. Through a period of almost ten reigns, this dearth of literary power continued. Five Henrys, three Edwards, Richard of Gloucester, and Mary held England's sceptre in this interval, but no sovereign singer touched the harp with fascinating mastery under their sway. Strangely enough, however, at this very season, when literature in England stood lowest among the influences of life, in Scotland there was a brilliant outburst of poetic productiveness remarkable for simplicity of spirit, lyrical fluency, patriotic fervour, and original excellence. James I. carried the infection of verse-making from London and Windsor to Stirling and Falkland, and then poetic inspiration gave grace to the literature of his northern kingdom. No poems of equal merit to "The King's Quhair" of James I., and the "Testament of Fair Cresseid" by Robert Henryson, the "Wallace" of Blind Harry, and "the Golden Targe" of Dunbar, can be named as products of the English muse of that barren era. In the long dreary night of England's literary winter, the northern lights illuminated the sky with variegated brightness and auroral activity.

There can be little doubt that it was a great advantage to Scotland, by direct and immediate contemporaneous influences, to have its vernacular literature and its language brought into living relations with the higher minds of the island, and to be stirred up to emulation of the highest efforts which had as yet been made there. Thus the language of Scotland was leavened with the choicest elements of grace, energy, intelligence, and imagination; and instead of growing up from the wild scions of its own climate, had the benefit gained by transplanted seeds. That the king on the throne and the blind mendicant alike spoke, wrote, and diffused poetry among the people, gave it a general influence, and, without doubt, inspirited the people with that love of minstrelsy which has made the rude picturesque energy and the sweet simple pathos of the ballad and the lyric the products of the hill-side, the farm, and the workshop, and made poetry a real and lifelike power throughout Scotland.

The most eminent of all the early Scottish poets for liveliness of fancy, richness of language, and variousness of power—William Dunbar—supplies us, in his "Lament for the Makaris" (*i.e.* poets), with the names of those who in early Scottish literature had acquired repute for their verses. Among those named is "The gude Syr Hugh of Eglintoun," regarding whom entries frequently appear in the "Accounts of the Great Chamberlains of Scotland" (1348–75), and who was connected with the court in the reigns of David II. and Robert II. He was in 1374 co-auditor of exchequer with John Barbour. His wife was Egidia, half-sister of Robert II. Of the poems which he wrote we have no certain knowledge. Heriot, of whom nothing is now known, is next named. Maister John Clerk and John Affleck are referred to as writers of ballad and tragic poetry, but only one *relique* of Clerk's remains. Dunbar mentions and mourns Barbour, Blind Harry, and Henryson. He names Sir Richard Holland, to the story of whose "Howlet" Blind Harry makes Stewart refer in his dispute with Wallace before the battle of Falkirk, saying:—

> "A Howlat complained of his *fethrame* [=plumage]
> Whilk Dame Nature took off ilk bird, bot blame,
> A fayre feather, and to the howlat gaiff;
> Then he, through pride, *reboytit* all the laiff" [=scorned].

Of Syr Mungo Lockhart of the Lee we have no remains, nor is his name enrolled in the ancient and honourable family which holds "the Lee penny" as an heirloom. "Clerk of Tranent," "that made the Anteris of Gawane," a metrical romance written in thirteen-lined stanzas, in alternate rhyme and with much alliteration, of which two cantos are (probably) still extant, is thereby made something more than a name. But of Browne, "Sandy Traill," Sir John Ross, and Gilbert Hay all except the name is gone. Patrick Johnstone's "Three dead Powis" still deliver their sad moralities on mortality to us; Mersar's "Perils in Paramours" alone is left of him "that did of love so lively write, so short, so quick, of sentence high;" Quintin Schaw's "Advice to a Courtier" is only a leaflet; and "gentle Stobo," "Roull of Aberdeen," and "gentle Roull of Corstorphine," of whom Dunbar affirms "two better fellows did no man see," are unrepresented by any surviving work. Walter Kennedy of Carrick contributes his share to the extraordinary though unrefined wit-combat of "The Flyting of Dunbar and Kennedy."

The "Orygynale Cronykil of Scotland," which records the history of the author's native land, owes its existence to the suggestion of the chief of the famous Fifeshire family of Wemyss. The author says:—

> "This tretys sympylly
> I made at the instans of a larde
> That had my servis in his warde;
> Schyr Jhone of the Wemys be rycht name,
> An honest knycht and of gude fame."

This was probably Sir John Wemyss of Rires and Kincaldrum, sheriff of Fife, who took possession of his ancestral estate in 1375. The writer was, in all likelihood, a native of the small village of Winton in Haddingtonshire, who, having entered the church, acted as chaplain to the Laird of Wemyss, and was aided by the sheriff to advancement in the locality where he had interest. Of himself the chronicler tells us that his "name" is—

> "Be baptysyme, Androwe of Wyntoune,
> Of Sanct Androwys a chanowne
> Regulare, bot nocht forthi [=nevertheless]
> Of thaim all, the least worthy;
> Bot of thare grace and thayre favoure
> I was, but meryt, mayde priowre
> Of the Ynche wyth-in-Loch-lewyne,
> Havand thereof my lytil ewyne
> Of Sanct Androwys dyocesy
> Betwene the Lomownde and Benarty."

Of the five subordinate priories belonging to St. Andrews, that of St. Serf's, in the isle of Lochleven, was the foremost. It had been an old religious house under the Culdees, and in the beautiful monastery there, surrounded by forty-eight acres of grain-land lapped by the waters gathered in "the howe of the Lomonds," the prior of St. Serf's occupied his learned leisure in drawing up these historic books, arranged, not, like those of Herodotus, in compliment to the nine muses, but

> "In honoure of the orderys nyne
> Of the holy angels, whilk the dywine
> Scripture 'lowys; on liké wyse
> I will dispart now this tretys
> In Nyne Buiks and in nocht ma,
> And the first book of tha
> Sall tret fra the begynnyng
> Of the warld."

He does commence with the creation, and in a singular mixture of sacred and profane history tells the story of the antique world, filling his first four books with the narrative from the formation of the first Adam to the birth of "the last Adam" (Jesus Christ), and only having an interjaculatory sentence or two occasionally on Scottish affairs. He proceeds to run into rhyme King Alfred's "Orosius," the chronicles of Peter Comestor, Martinus Polonus, &c., and when he reaches his own land and time he occupies his pages—bringing the record down to the death of Robert, duke of Albany (1420)—

> "With Inglis and Scottis storys syne."

Among others he supplies us with this early form of the Macbeth myth (which we find ourselves compelled greatly to condense). Of Macbeth-Finlay, "when he was young" and "dwelling with the king," his uncle Duncan, who—"for he was his sister's son"—treated him well, he tells us that

> "Ae nicht in his dreaming . . . .
> He saw three women bye ganging;

And they women, then thocht he
Three weird sisters maist like to be.
The first, he heard say (ganging bye),
Lo! yonder the Thane of Crombuwtye!
The other woman said, again,
Of Moray, yonder I see the Thane.
The third then said—I see the king.
All this he heard in his dreaming . . . .
Soon after that, in his youthhead,
Of these Thanedoms he thane was made.
Syne next he thoughté to be king . . . .
The fantasye thus of his dream
Moved him maist to slay his Eme [=uncle].

. . . .

Alle thus when his Eme was dead
He succeeded in his stead,
And seventeen winters full reignand
As king he was in till Scotland.

. . . .

And he the devil was that him gat,
He bade her (his mother) nought to be flayed of that,
But said that here sonné should be
A man of great state and bounty,
And nae man should be born of wife
Of power to reive him of his life.

. . . .

And when to rise he first began
His Eme's sonnés twa lawful then
For doubt out of the country fled."

He then tells how they were received courteously by Edward the Confessor; how Macbeth, eager to build a great castle "upon the height of Dunsinane," compelled his barons to supply free labour; how Macduff rebelled, and aided by his wife's connivance escaped to England; how he besought Malcolm to assert his rights, how Malcolm traduced himself to try Macduff's good faith, and how Edward with love and good will

"Bade the Lord of Northumberland,
Sir Siward, to rise with all his might,
In Malcolm's help to win his right.

. . . .

Syne they heard that Macbeth aye
In phantom-*freits* had great fay,
And truth held in such fantasy,
Be that he trowèd steadfastly,
Never discomfited to be,
Till with his eynè he should see
The wood brought of Brinane
To the hill of Dunsinane."

Macbeth, aghast, saw this "flitting wood" and "took to flight." They chased him to the wood of Lumphanan. There he rallied, and remembering the charmed life he bore, announced his "charmed life," only to be told of the hopelessness of his case.

"Thus Macbeth slew they than
In the wood of Lumphanan,
And his head they struck off there,
And that, with them, from thence they bare
To Kincardine, where the king
Till their gain-come made biding."

This is the "original chronicle" of that story which Boethius dignified with classical Latinity; Buchanan, while thinking it fitter for the stage than for a historic volume, set in language rivalling that of Livy's pictured pages; Holinshed enlarged and translated into English, and the genius of Shakspeare has dramatized in one of the grandest tragedies in any tongue. The last four books are devoted to Scotland. Though Wyntoun interweaves a good many fabulous legends with his racy octosyllabic verse, he supplies, on the whole, a clear and trustworthy historical record of the main events of the home life and foreign relations of North Britain. He speaks of preceding writers—especially Barbour—with much respect; often praises the gallantry of the English, and introduces into his pages the results of a wide course of miscellaneous reading and of perusal of documentary evidence. His works are of considerable philological value, enabling us to compare his composition with that of contemporary English writers, and to estimate, in some measure, the extent of scholarship attainable in Scotland, in an age prior to the existence of any northern university. Comparison of his statements with those of the "Scotochronicon" by John Fordun, continued by Walter Bower, the Register of the priory of St. Andrews, and the *Fœdera Angliæ* leads to the conclusion that he was as accurate in his history as he was animated in his verses.

It is only by inference that we can make out the period at which Henry the Minstrel composed his Wallace epic. Buchanan informs us that in 1524 he studied at St. Andrew's under John Major, who was at that time *in extrema senectute.* Major, however, still survived as provost of St. Salvator's College in 1549. If we regard "extreme old age," gauged by a young man, to be somewhat more than "three score years and ten," Major would seem to have lived to, at least, ninety-five. The date of his birth has not been ascertained, but this calculation would lead us to assign that event to 1454. This aged historian says that "in the time of his infancy," Henry, a man blind from his birth, composed a whole book concerning William Wallace, and collected those things which were told of him in common *legends* into vernacular rhyme, in which he was an adept—"but I only in part give credit to traditionary tales: this author by the recitation of these stories in the presence of men of high rank obtained food and raiment, of which he was worthy." While therefore Major was under seven years of age, or about 1460, Harry the Minstrel was, we may conclude, employed in reciting the doughty deeds of the valiant Sir William Wallace in the halls of the nobles and gentry of the reigns of James III. and James IV., the latter of whom, at least, bestowed occasional donations on the blind bard, as we learn from some of the treasurer's accounts of 1492. The only MS. of his poem is dated 1488, and it seems to have been transcribed from his own recitation. Shortly after this period, Henry seems to have died. He was, at least, dead prior to 1508, when Dunbar names him in his "Lament for the Makaris." He describes himself as a *bural* or *borel* man, *i.e.* a poor common layman, though his knowledge of Latin, in that age, might have led to the inference that he was a cleric. The minstrel lays claim to no originality in the matter of his song. The authorities on whom he relied for his facts were Mr. John Blair, "a worthy clerk both wise and right sage," who had been a schoolfellow with and an adherent of Wallace, and had lived

"Before in Paris toune
Among maisters in science and renoune.

. . . .

He was the man that principally undertook,
That first compiled in dyt the Latine book
Of Wallace' lyfe, right famous of renoune,
And Thomas Grey, parson of Libertoune,
With him they were · and put in story all,
Oft ane or both, mickle of his travaille."

Again, he says towards the conclusion of his poetic narrative,

"Of Wallace' lyfe, who has a further feil [=fulness of knowledge]
May show forth more with wit and eloquence:
For I, to this, have done my diligence,
After the proof given from the Latine book,
Whilk Maister Blair, in his time undertook
In fair Latine compilled it till an end;
With these witness the more is to commend.
Bishop Sinclair then Lord was of Dunkel;
He got this book, and confirmed it himsel'
For very truth: thereof he had no dread,
Himself has seen great part of Wallace' deed.
His purpose was to have sent it to Rome,
Our Father of Kirk thereon to give his doom [=judgment].
But Maister Blair and als Sir Thomas Gray,
After Wallace, they lasted many a day.
These two knew best of Sir William's deed
From sixteen year while nine and twenty gaed" [=went].

The national fervour and patriotism of the Homer of Scotland is powerfully and beautifully expressed in the opening lines—which, as a specimen of the language, we reproduce from John Ramsay's MS. of 1488, as given in Moir's edition of Schir William Wallace for the Scottish Text Society.

"Our antecessouris, that we suld of reide,
And hold in mynde thar nobille worthi deid,
We lat ourslide, throw werray sleuthfulnes,
And castis ws evir till uthir besynes.

Till honour ennymyis is our haile entent,
It has beyne seyne in thir tymys by went;
Our ald ennemys cummyn of Saxonys blud,
That neuyr yeit to Scotland wuld do gud,
Bot euir on fors, and contrar haile thair will,
Quhaw gret kindness thar has beyne kyth thaim till.
It is weyle knowyne on mony diuers syde,
How thai haff wrocht in to thair mychty pryde,
To hald Scotlande at wndyr evirmar.
Bot God abuff has maid thar mycht to par:
Yhit we suld thynk on our bears befor,
Of thair parablys as now I say no mor."

This extract from the beginning of the third book will show the poetical form into which the blind minstrel could mould the language of that earlier time:—

'In joyous July, when the flowèr's sweete
Digestable, engendered thro' the heate,
Both herbe and fruite, bush and boughès braid
Abundantly in every slouk and slaid [= vale and plain]
As bestial, their right course to endure
Well helpèd are by working of Nature,
On foot, and wings ascending to the height
Conserved well by the Maker of might;
Fishes in flood, refecked royally [= prepared]
Till mannès foode, the world should occupy.
But Scotland so was wasted many a day,
Through war such skaith, that labour was away.
Victuals *worthe* scant or August could appear [= had become]
Through all the land, that food was happened dear:
But Englishmen, that riches wanted nane,
By carriage brought their victual full good main;
Stuffèd houses with wine and good *vernage* [home-grown crops]
Demanding this land as their own heritage;
The country wholly they ruled at their will,
Messengers then such tidings brought them till;
And told Percy, that Wallace living were,
Of his escape from their prison in Ayr."

Henry's book is living and impassioned, with a good deal of improvisatorial roughness and make-rhyme; but still vigorously versified and boldly, even exaggeratedly, sensational. Through his eleven books swords flash, blood flows, blows fall, fight follows fight, death-dealing carnage appears everywhere. He rejoices in slaughter and riots in the clangour of war. Of the stirring enthusiasm of the bard we can get no shorter specimen than the lines on the defeat of the English at Stirling Bridge. As the bridge yielded when the hosts crossed over it, and the fatal immersion overtook the English,

"A hideous cry amang the people rose,
Both horse and men into the water fell.
The hardy Scots that would no longer dwell [= delay]
Set on the laive, with strokes sad and sair,
Of them there owre, as then suffered they were.
At the fore-breist they proved hardily
Wallace and Graham, Boyd, Ramsay, and Lundy;
All in the stowre fast fighting face to face,
The Southron host back reared off that place,
That they first took five acres broad and more
Wallace on foot, a great sharp spear he bore;
Among the thickest of the press he gaes [= goes]
On Kertinghame a stroke chosen he has,
In the *burneis*, that polished was full bright [= cuirass]
The pungent head, the platès piercèd right,
Through the body stickèd him—but rescue;
Dreadfully to death that chieftain was *adew* [= done]
Both man and horse at that stroke he bore downe.
The English host, which were in battle *bound* [= engaged]
Comfort they lost when their chieftain was slain,
And many a one to flee began, in plain.
Yet worthy men 'bode still into the *stede* [= place]
While ten thousand was brought on to their deade,
Then fled the laive, and might no longer bide,
Succour they sought on many divers side,
Some east, some west, and some fled to the north,
Seven thousand large at once *floitered* in Forth [= floundered]
Plunged in the deep and drowned without mercyè,
None left in life of all that full *menyié* [= crowd]
Of Wallace' host no man was slain of vail [= value, rank]
But Andrew Murray into that strong *battaile*."

Blind Harry has invested the traditionary tales of the peasantry regarding "Wallace wight" with the living charm of enthusiastic admiration, and yet singularly enough a great many of the transactions narrated by him, which had come to be regarded as fictitious, have been authenticated—*e.g.* Wallace's expedition into France—by recent discoveries. It may be granted that Henry the Minstrel was more patriot than poet; but the Scotch blood leaps in the veins of those who read his free and fine heroic couplets, in the use of which he was the first Scottish poet to follow Chaucer.

James I., king of Scotland, the third son of Robert III. and Annabella Drummond, his wife, was born at Dunfermline, in July, 1394. His brother John had died in infancy, and David, the eldest son and heir to the crown was, as all readers of "The Fair Maid of Perth" will remember, put to a cruel death by his uncle, the Duke of Albany, in 1402. James, who thus, in his eighth year, became heir to the throne, was early placed under the tuition of Henry Wardlaw, founder of the University of St. Andrews. Fearing Albany's treachery, Robert III. resolved to send his son to the court of Charles VI. for safety as well as for training. Sinclair, earl of Orkney, and Sir David Fleming of Cumbernauld, in March, 1405, took the prince to the Bass Rock, at the mouth of the Firth of Forth, whence, with Orkney and a few friends, James went on board a vessel bound for France. Fleming, while returning from the scene of the embarkation, was assassinated at Long-Hermandstone by Albany's emissaries. At sea, off Flamborough Head, the ship which carried James was seized by John Jolyff, a merchant-adventurer of the port of Clay. He was taken by his captors to the court of Henry IV., who sympathized with Albany. Orkney remonstrated in vain against his prince being, in time of truce, so seized. Henry jestingly stated that if he were only going to France to be educated, he could be as well taught in England as over the sea. James was conveyed to Pevensey Castle in Sussex, and put in charge of Sir John Pelham. He was trained with singular care, though retained as a prisoner. Robert III. died, it is said of grief, in Rothesay Castle, Bute, 4th April, 1406. James was now king of Scotland, and Albany assumed the title of governor. Probably the governor's interest in the personator of Richard II. at the Scottish court was mainly influenced by a sort of mutual, though it may be tacit, understanding that so long as James was kept safely in England, little trouble would cross the border on Richard's account. Henry IV. died 1414. Henry V. had James immediately removed to the Tower, but when he went to assert his claims in France he carried James with him. James acted as chief mourner in the magnificent funeral procession with which the remains of Henry were brought from Vincennes to Westminster. The Duke of Bedford reponed James to captivity in Windsor Castle. Here, in May, he strove to school himself with Boethius' "Consolations of Philosophy," and began to lessen life's listlessness by writing in rhyme after the fashion of Chaucer and Gower, both of whom he had learned to appreciate. Thus "The King's Quhair" was begun, to beguile the weary hours, and with little other aim.

He lay sleeplessly, reflecting on his wayward fate, read in search of philosophic calm, mused on the fickleness of fortune, and seems to have intended to compose a lament on his captive condition. He rose, went to the window, looked out, was delighted by the early morning's beauty and sweetness. He translated the twitter of the birds into this verse:—

"Worschippè! ye that loveris beene, this May,
For of your blisse the Kalends are begonne,
And sing with us, away, winter, away!
Come, sommer, come, the sweete seasoun and sonne!
Awake for schame! that have your heavynesse wonne,
And amorously lift up your headis all,
Thank love, that list you to his merry call.'

This set him to think of what love is, and why poets so sing of it. His thoughts thus turned received an answer speedily; for casting down his eyes into the garden, his "wittis all were so overcome with pleasance and delyghte" at seeing "a sweete face," that he instantly exclaimed,

"Ah! Sweete, are ye a worldly creature,
Or heavenlie thing in likenesse of nature,
Or are ye the god Cupid's own princesse,
And coming are to loose me out of bond—
Or are ye very Nature, the goddesse,

That have depainted with your heavenlie hand
This garden full of flowers as they stand?
What shall I think allase! What reverence
Shall I ministere to your excellence?"

He instantly felt the power of her beauty, and knew that, captive as he was, he was again, and this time willingly, enthralled. He thus describes the peerless lady:—

'Of her array, the form gif I shall write
Toward her golden haire and rich attire
In fret-wise couchéd was with pearlis white
And great *balas* lemming as the fire [= rubies shining]
With many an emerant and faire sapphire;
And on her head a chaplet fresche of hue
Of plumés parted red and white and blue.

Full of quaking spankles bright as gold,
Forgéd of schape like to the *amorettes* [= penny-cress]
So new, so fresche, so pleasant to behold,
The plumés eke like to the flower *Jonettes* [St. John's wort]
And other of schape like to the round *crochettes* [knobs]
And above all this, there was, well I wotte,
Beauty enough to make a world to dote.

About her neck, white as the faire *amaille* [= enamel]
A goodlye chayne of small *orfevrerie* [goldsmith's work]
Wherebye there hung a rubie, without faille
Like to an herté schapen verilye,
That, as a spark of love, so wantonly
Seemed burning upon her whité throte
Now gif there was gude partye—God it wotte!

And for to walk that fresche Mayes' morrow
An *huke* she had upon her tissue white [= clasp]
That goodliére had nought been seene beforawe,
As I suppose; and girt she was a lyte
Thus halflyns loose for haste, to such delight
It was to see her youth in goodlihoode
That for rudeness, to speak thereof I dreade.

In her was youth, beauty, with humble aport,
Bounty, richesse, and womanly feature,
God better wotte, than my pen can report;
Wisdom, largesse, estate, and cunning sure
In every point, so guided her measure
In word, in deede, in schape, in countenance
That nature might no more her childe advance."

This was Lady Joanna Beaufort, daughter of the Earl of Somerset and Margaret Holland, whom afterwards—on 2nd February, 1424—James married in the church of St. Mary Overies (St. Saviour's, Southwark), and received as her marriage portion a discharge for £10,000 of his ransom-money, which had been fixed by the Duke of Bedford at £40,000, payable in twelve half-yearly instalments. Thus the royal lover expresses his joy at the happy chance which brought him a spouse—

"Thankit be the fair castle wall
Where as I whilome lookéd forth and leant;
Thankit mot be the Saints Marchiall [= of the month of March]
That me first causit hath this accident;
Thankit mot be the greené boughis bent
Through whom and under, first fortunéd me
My heartis health and my comfort to be."

Of course success did not come to him all at once. He praised Venus, he apostrophized the lady, saw her depart, was dull all day, dreamed all night; and in his dream was carried up to the palace of Venus, who sends him, accompanied by Good Hope, to Minerva, whose favour he gained. Suddenly, however, he finds himself on earth again, wandering in quest of fortune. On his way Good Hope befriended him and led him to Fortune's castle, where she was superintending her wheel. He saw it whirling, and those who placed their feet upon its slippery spokes rising, falling, and being thrown off. She named him, put him on the wheel, and—he awakes. A turtle-dove brings him an encouraging message, and his delight is unbounded at his good fortune. He dedicates his "little treatise, naked of eloquence,"

"Unto the *impnis* of my maisteris dear [= scions, sons]
Gowere and Chaucere, that on the steppes satt
Of rhetorike, while they were living here,
Superlative as poets laureate,
In morality and eloquence ornate,
I recommend my book in lines seven,
And eke their souls into the blisse of heaven."

After an exile of nineteen years James entered his native land 1st April, 1424, and was, on 21st May, crowned at Scone. He was the ablest of the Stuart dynasty, and under his rule the internal affairs of Scotland were conducted with a vigour and a wisdom which had not previously been known. With his reign the first regular series of the statutes of the Scottish parliament may be said to begin. The stern sway he exercised in a land where turbulence was chronic secured enmity and excited to treasonable action. Though, for a time, he managed to maintain power and peace, at length the revengeful spirit of those who had suffered from his severity led to the formation of a conspiracy, and he was slain by a band of ruffians instigated by Sir Robert Graham, on the evening of a festival held in Perth, in the monastery of the Black Friars, in 1437, in the forty-fourth year of his age.

Two other poems of considerable length, and in a distinctly different style, have also been attributed by some authors to James I.—"Peebles to the Play," and "Christ's Kirk on the Green." These are both in the Scottish dialect; the former is a playful poem descriptive of the humours of the festival of Beltane or May-day, at which rustic sports and pastimes were held amidst noisy signs of popular enjoyment, as these were performed at Peebles, on the borders of the Ettrick Forest; and the latter a burlesque narrative of the merry-making carried on at the Kirktown of Leslie, near Falkland in Fife, in the neighbourhood of the royal palace. George Bannatyne's MS. of 1568 expressly assigns the latter to James I., and John Major appears to assign the former by quoting the two first words of it as a sufficient indication of the poem meant, which was assuredly widely-known and popular. If the one ascription is right the other is probably so, as the spirit, tone, and language of both are very much alike. Many critics, however, incline to regard James V., "the King of the Commons," as more likely to be their author. It would be impossible to enter into minute matters of subtle disputation in the space at our disposal. There seems no real unlikelihood that a man of genius and versatility of mind like James I. should be their author, while any argument derived from their greater modernness of linguistic forms is weakened by the fact that they are only known in a transcribed form, written nearly 120 years after that sovereign's tragic death. As it will afford opportunity for quoting a specimen stanza of "Peebles to the Play," we note the strong objection of J. Sibbald in his "Chronicle of Scottish Poetry," viz., that as short *curches* with little *hudes*, such as are used in Flanders, England, and other countries, were in 1457 commanded, in a sumptuary act, to be worn by "the daughters of men living in burghs and of landwart," the following verse could scarcely have been written prior to that date as a scene in the real life of Scotland:—

"All the wenches of the west
Were up ere the cock crew;
For reeling there might nae man rest
For garray and for glew;
Ane said my *curches* are not prest,
Then answered Meg full blew,
To get a *hude* I hold it best,
By God's soul that is true,
Quoth she,
Of Peebles to the Play."

It may be as well here to quote one stanza from "Christ's Kirk on the Green" as a companion picture:—

"To dance these damsellis them dight,
These lasses light o' *laits*, [=manners]
Their gloves were of the *rae-fell* right, [=doeskin]
Their shoon were of the Straits, [*i.e.* from Morocco]
Their kirtles were of Lincoln light,
Weel pressed with many plaits;
They were so nice, when men them *night* [=came nigh]
They squealed like ony *gaits* [=goats]
So loud,
At Christ's Kirk on the Green that day!"

Robert Henryson, "Scholemaister of Dunfermline," was a poet conspicuous for simplicity of taste. felicity of language,

and fine fancy. He entered the University of Glasgow in 1462, being then a licentiate and a bachelor. He speaks of himself in his chief work as "ane man of age," and we know from Dunbar that he had died prior to 1508. His earliest productions in verse appear to be a rather pedagogical collection of thirteen fables, first published by Andro Hart in 1621 as "The Moral Fables of Æsop the Phrygian, Compyld into eloquent and ornamentall Meter. Newlie revised and corrected." They are ornately simple, archly amplified, replenished with political allusion, and elaborately moralized. A short sweet pastoral of his "Robyn and Makyn" has charmed the heart of the susceptible for upwards of three centuries. It is "silly soothe, and dallies with the innocence of love." A maiden woos a youth, who rejects her; but by and by he is brought to feel the fateful pangs of an earnest suitor for her affection. The ballad is couched in sprightly rhyme in this fashion:—

> "Robin sat on the gude green hill,
> Keepand a flock of Fee,
> When merry Makyn said him till,
> O Robin rew on me.
> I have thee lovéd baith loud and still
> These towmonths twa or three,
> My dule in dern but giff thou dill,
> Doubtless bot dreid I dee."

"The Abbey Walk" is solemn and impressive. "The Garment of Good Ladies" compares female ornaments with female virtues with long-drawn-out ingenious iteration. "The Bluidy Serk" is a holy allegory of man's body and soul, sin and the grave, Lucifer and the Saviour. "Orpheus Kyng, and how he gaed to Heaven and to Hell to seeke his Queen," is a thin, shadowy, somewhat feeble poem, representing "the part intellective of man's soul in search of happiness," as fabled in the legend of the Thracian king and his Eurydice. His masterpiece is "The Testament of Creissid," a sequel to Chaucer's "Troilus and Cresseyde," in which the northern poet relates the punishment of the fair but false daughter of Calchas. Cupid announces it in these words:—

> "Thus shalt thou go begging from house to house,
> With cup and clapper like a Lazarous."

This is the poem from which Shakspeare learned that "Cressida was a beggar" ("Twelfth Night," iii. 1). The interview in which his "sometime darling" begs from Troilus and is the recipient of a rich almesse from him—

> "And nevertheless not one the other knew,"

is one of the most touchingly conceived incidents in the poetry of romance.

Walter Kennedy, whom Gawin Douglas and Sir David Lindsay mention as among the greatest poets of their country, appears to have been a native of Carrick, in Ayr—a younger son of the first Lord Kennedy—and to have belonged to the church. He asserts in the "Flyting of Dunbar and Kennedy" that he has "land, stores, and stacks," "coulter and plough," "substance and gear;" that he is "of the king's blood," "his true especial Clerk," "faithful in allegiance to him," and lives in hope of even higher "guerdon, reward, and benefice" from his sovereign lord. In "Jock Up-a-land's Complaint against the Court in the Nonage of James V.," he supplies a sad view of the social state of Scotland in those days. Lord Hailes has preserved his "Praise of Aige." Ramsay supplies a copy of verses purporting to be Kennedy's "Invective against Mouth-thankfulness."

Of the personal history of William Dunbar the records are extremely scanty. Saltoun, in East Lothian, is sometimes given as his birthplace, and he is supposed to have been the grandson of Patrick Dunbar of Beil, the younger son of George, tenth earl of March. The possessions of the Dunbars were declared forfeit in the first parliament held by James I. at Perth, 10th June, 1434–35. This circumstance perhaps accounts for James I.'s exclusion from his "Lament." Dunbar, who was probably born about 1460, was early destined for the church. He was in 1475 a student in St. Andrews, and in 1479, as an M.A., became entitled to the designation *Maister*. As a novice on the order of St. Francis, he, under direction of the Grey Friars of Edinburgh, took a begging pilgrimage as a pardoner through the south of Scotland, the populous towns of England, crossed the Channel and taught in Picardy. But friar's weeds did not suit him, and he became a hanger-on of the court, acting as a secretarial agent in several embassies to foreign states under James IV., and hunting for a benefice meanwhile. Here are two stanzas in which he very directly states his case:—

> "I knaw nocht how the Kirk is guydit,
> Bot benefices are nocht leill devydit;
> Some men has seven and I nocht ane—
> Quhilk to consider is a pain!
> Great abbeys graith I will to gather
> Bot ane kirk scant covered with heather,
> For I of littel would be fain—
> Quhilk to consider is a pain!"

After 1500 his services were recognized by an annual pension of £10, subsequently raised to £20, then to £80. He had the rare good fortune of having some of his poems printed in one of the earliest volumes issued from the Scottish press by Chepman and Millar. Sir David Lindsay speaks of him as dead in 1530. Sir Walter Scott regarded him as "the darling of the Scottish muses."

On the marriage of James IV. to the Princess Margaret of England, Dunbar celebrated that auspicious event in a fine poem entitled "The Thistle and the Rose." It is a boldly inventive emblematic poem, of much richness of fancy and beauty of language. As Dr. Langhorne says—

> "In nervous strains Dunbar's bold music flows,
> And Time still spares 'The Thistle and the Rose.'"

It begins with a picturesque passage descriptive of the appearance of nature in "lusty May that mother is of flowers," who commands him to "do observance" to "the rose of most pleasance." Nature commands the elements to be propitious. Beast, bird, and flower are summoned to her presence and appear in "the twinkleyn of ane e'e;" and first the real Scottish "Lyone, greatest of degree."

> "This awfull beist full terrible was of cheer,
> Piercing of look and stout of countenance,
> Ryght strong of corps, of fashion fair but fier[ce],
> Lusty of schape, lycht of deliverance,
> Red of his colour, as is the ruby glance;
> On field of gold he stood full michtily,
> With fleur-de-lyse encircled lustily."

Nature ordained him "the King of Beists;" "syne crowned she the Eagle, King of Fowls," then "the awful Thrissil she beheld," and seeing him "keepit (guarded) with a bunch of spears," appointed him sovereign defender of the flowers, but commanding him to

> "Hold none other flower in such daintye
> As the fresche Rose, of colour red and white.
>
> . . . .
>
> Considering that no flower is so perfyte,
> So full of virtue, pleasance, and delight,
> So rich in blissful and angelick beautye,
> Imperial birth, honour, and dignitye.
>
> . . . .
>
> Hail herbs Empresse, hail freschest Queen of flowers,
> To thee be glory and honour at alle hours."

"The Golden Targe" is a moral allegory, in which Cupid, Venus, youth, beauty, presence, dissimulation, homeliness, and danger, are among the characters who assail the poet's protector from the power of love. He is "reason, with shield of gold so clear, in plate of mail, as Mars omnipotent." All fail to pierce the golden targe which reason holds before him as a defence until "presence cast ane powdr in his eyne." Then reason begins to reel, danger hands the poet over to grief, Eolus blows his bugle, the winds rise, the persons of the dream-drama rush upon shipboard, fire guns, and the poet awakes with the noise and terror to find everything calm and beautiful "in mirthful May."

His "Dance" [of the seven deadly sins] is a series of most graphic personations done in freehand with a few broad, telling, and effective strokes. In it, "pryde, with bare wyld back and bonnet on syde," "Heillie harlottes" and priests

"with bare shaven necks;" Ire, accompanied with "boasters, braggers, and barganers; envy, flatterers and backbiters; covetyse, root of all evil and ground of vice;" sloth (sweerness) full sleepy, but flogged into "a heat" by Belial; heresy led by idleness and "the foul monster gluttony," and many "a waistless wally drag with names unweildable," all dance before "Mahoun." These, however, with Highlanders and Irishmen who took part in the sports, were so noisy that "he smored them with smoke." "The Twa Married Women and the Widow," in the old alliterative rhythm of the Anglo-Saxon poets, is a coarsely humorous satire on these three gay ladies. "The Flyting of Dunbar and Kennedy" is a witty word-warfare of most expressive vernacular outspokenness, and seems as if each had vented the vilest vocabulary he had at his rival's character. It is a trial of skill in wicked waggery, and does not imply that they had hostile feelings towards each other.

Dunbar's poems are varied in form and matter, masculine, terse, original, and musical; strong, distinct, pawkie, wicked, and wise. Some of his smaller pieces are songs of love, others holy hymns; some are Horatian in humour, others hilariously Rabelaisian; some are racy, others pathetic, and a number of them fall into Macaronic rhyme, a jocose intermixture of English and Latin often highly amusing. He has accomplished no great masterpiece, but many exquisite miniatures, and is in versatility and power a Scottish comrade for Chaucer.

It is worth noting that at the end of "The Golden Targe" he not only speaks of the language he uses as English, but of himself as a disciple of Chaucer.

> "O reverend Chaucer, rose of rhetoric, alle
> As in our tongue a flower imperial
> That rose in Britayne ever, who readés right
> Thou bearest of Makkars the triumphs royal;
> Thy fresh enamelled terms celestial
> This matter could illumined have full bright,
> Wast thou not of our English all the light
> Surmounting every tongue terrestrial
> As far as Mayés morrow does midnight."

Gawin Douglas, bishop of Dunkeld, on the other hand regarded himself as a follower of Barbour and the more national bards in a style which he endeavoured to enrich and elevate by an infusion of Latin and French into the native dialect of Lowland Scotland. His masterly translation of the Æneid (1513), the earliest metrical version of any ancient classic which appeared in either kingdom, he speaks of as

> "Written in the language of the Scottish nation,
> Keeping no southern but our own language."

This is rather an echo of the political than of the poetical feeling of the time. Douglas was the third son of Archibald fifth earl of Angus. He was born at Brechin in 1474, was educated for the church, became rector of Hawick, 1496, provost of the Collegiate Church of St. Giles, Edinburgh, 1509, abbot of Aberbrothock, 1514, and bishop of Dunkeld, 1515. He was accused of treasonable complicity in bringing papal bulls into Scotland, and was imprisoned for a year in Edinburgh Castle. He escaped to England, was pensioned by Henry VIII., died of the plague in London, 1522, and was interred in the Savoy Church. Before 1501 he had translated Ovid's "Remedy of Love"—not now extant; his version of the Æneid, suggested by Henry first Lord Sinclair, was completed in eighteen months. It contains not only the Virgilian books, but the supplementary one composed by Mapheus Vigius. To each of the books a prologue is prefixed, and these contain some of the happiest products of his muse. His "Palace of Honour"—probably founded on the "Séjour d'Honneur" of Octavien de St. Gelais, is an allegorical poem on the vanity of earthly things, and on virtue as the true pathway to happiness. It is an early Pilgrim's Progress. "King Hart" is a long metaphor. The heart is the sovereign of life, and his court is the affections that move in it. Queen Pleasance acquires his favour, and he marries her. Age accompanied by conscience come to the court. The queen flies. Decrepitude attacks the king and wounds him. He makes his will and death vanquishes him. Both were intended to influence James IV.

Sir David Lindsay was first the tutor and afterwards the counsellor and favourite of the accomplished but unfortunate James V. He was born of the noble family of Lindsay of Byers, at the Mount near Cupar-Fife, and was educated at St. Andrews (1505–9). In 1512 he was appointed tutor to the prince, an office which he held for twelve years. His tales, plays, and other poetical productions, though not marked by high imaginative power, abound in broad humour, and display infinite variety of witty invention and satirical capacity. He infused a dash of merriment into the melancholy life of the dismal days of pre-reformation Scotland. Many of the pithy passages of his poems have passed into popular proverbs. His chief productions are "The Dreme" (1528), in the Chaucerian metre; "The Complaynt" (1529), and "The Complaint of the King's Papingo" (peacock), 1530—three moralizings upon the state and government of Scotland during the minorities of the hero of the fatal field of Flodden, and of the King of the Commons. His play (or satire) of the "Three Estates" (1535) was performed, in the open air, before the king, queen, and court, at Cupar, Linlithgow, Perth, and Edinburgh, and is a most pungent exposure of the abuses introduced into government by king, nobles, and clergy. This extraordinary performance lasted a whole day, and is scathing, gross, powerful, and humorous. This, and "Kitty's Confession" (1541), contributed largely to the progress of the reformation in Scotland. They were in fact, in the words of Sir Walter Scott, full of

> "That satiric rage,
> Which bursting on the early stage,
> Branded the vices of the age,
> And broke the keys of Rome."

"Squire Meldrum"—the latest specimen of the metrical romance—with a spice of Hudibrasticism in it, is founded on an incident in real life, which Pitscottie relates as having occurred about 1518, naming the chief parties as William Meldrum, laird of Binns; Luke Stirling, nephew of the Laird of Keir; and Lady Glenaigles, daughter of Mr. Richard Lawsone of Humbie, provost of Edinburgh. "The Monarchie" (1553), in "A Dialogue between Experience and a Courtier of the Miserable Estate of the World," contrives to convey in rhyme a sort of philosophy of history, and to employ the story of the past for the instruction of his own age in the right principles of government. Other poems by Lindsay are an "Answer to the King's Flyting"—his part of a metrical scolding-match between himself and the royal poet, who (as he said in another place)

> "Writes, in ornate style poetical,
> Quick, flowing verse of rhetorical colours,
> So freshly springing in your lusty flowers,
> To the great comfort of all true Scotchmen;"

"Complaint of Basche, the King's Hound"—in which he inveighs against flattering favourites; "Supplication against Syde Tails and Muzzled (Veiled) Faces"—a sumptuary satire; the "Deploration of the Death of Queen Magdalene," who had died 7th July, 1537, within forty days after her arrival in Scotland; and "The Tragedy of Cardinal Beatoun, archbishop of St. Andrews, whereunto is joined the martyrdom of Maister George Wishart" (1546), in which the ghost of the cardinal relates the chief events of his life, and the author makes him give reformation lessons to prelates and princes.

In 1531 Lindsay was one of the ambassadors to the Netherlands for the concluding of a commercial treaty between the two countries. On his return he married a lady of the family of the Douglases; he was ambassador to Germany to choose a wife for the king in 1535; he conducted the pageants connected with the arrival of Mary of Guise into Scotland; he was member of Parliament for Cupar in 1544; ambassador to Denmark for help against the English in 1548, and died, after a few years of literary retirement, in 1558.

In the prologue to his "Complaint of the Papingo," Lindsay names several contemporary poets:—

> "Kidd in cunning and practice right prudent,
> And Stewart who desireth a stately style,
> Full ornate workés daily does compile.
> Stewart of Lorne will carp right curiously,
> Galbraith, Kinloch, when they list them apply
> Into that art, are crafty in ingirs."

These are all unknown except through this mention of them. Lindsay also asks,

> "Who can say more than Sir James Inglis says,
> In ballads, farces, and in pleasant plays?"

Of these, however, there are no remains, and though the Abbot of Culross (murdered 1531) has had assigned to him "The Complaint of Scotland," there is no real proof of his authorship of it.

Bannatyne's MS. has preserved some verses said to be by Stewart, but it is impossible to determine to which of them they should be ascribed. Lindsay had as his companion in court life

> "Ane cunning clerke which writeth craftily,
> A planete of poets callėd Ballentyne,
> Whose ornate writs my wits cannot define."

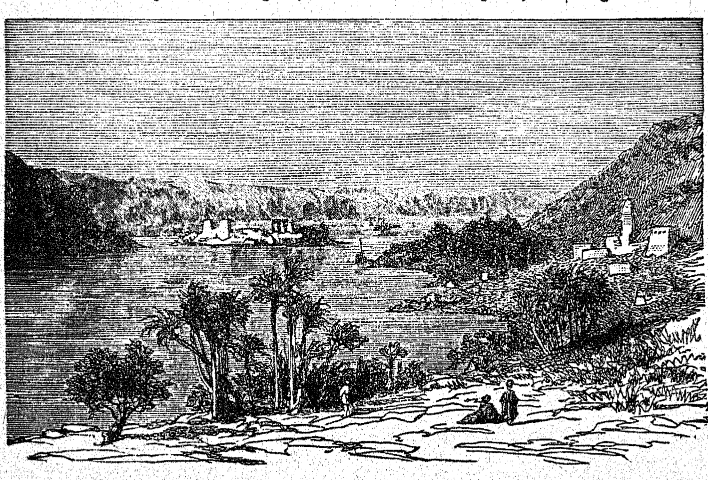
This was the Archdean of Moray and Canon of Ross, translator of Boethius' history and chronicle of Scotland, to the cosmographical and historical parts of which he prefixed a proemium; the former is largely indebted to the "choice of Hercules," and the latter deals with the uses and study of history—a theme continued in his proemium to his version of Livy. He also proceeded to some extent with a metrical version of Boethius.

Norval and Allan Watson are names which occur in Bannatyne's MS. Lord Hailes has published poems by Tethy, Fleming, and John Blyth. James V. was himself a poet—to whom the "Jolly Beggar" and the "Gaberlunzie Man" have been ascribed, and, as has been already stated, both "Christ's Kirk on the Greene" and "Peebles to the Play" are sometimes attributed to the "Gudeman of Ballengeich," whose court was a haunt for the Scottish muse. It was an age in which passion raged and self-will ruled—when manners were wild and life was turbulent. Incident followed hard on incident, and gained the immortality of remembrance only when the pathos or heroism of events was told in the rapid rush of the poetry of the ballad.

HISTORY.—CHAPTER VII.

EGYPT AND THE EGYPTIANS—THE AGE OF THE PHARAOHS—THE CASTES—THE PRIESTHOOD AND THE WORSHIP—THE PTOLEMIES—ARTS, SCIENCES, AND INDUSTRIES.

THE land of Egypt, properly speaking, is the valley of the Nile, from the lowest cataract upon that river to the sea; *i.e.*, it extends in length from about the twenty-fourth degree of northern latitude to a little north of the thirty-first. From the twenty-fourth degree, the latitude of Syene, to

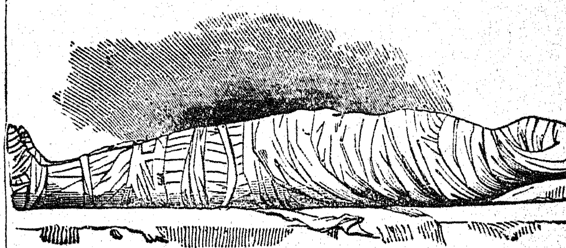


Banks of the Nile.

the thirtieth, the latitude of Cairo, or the apex of the Delta, the valley of the Nile is bounded by two nearly parallel ranges of hills, the utmost distance of which from each other never exceeds 24 geographical miles. From the thirtieth degree of latitude the river splits into various branches, which fall, or, in old times, fell into the sea by numerous embouchures. The land of Egypt proper, from the head of the Delta, consisted of two narrow strips of land, one along the eastern bank of the most easterly branch of the river, which fell into the sea about Pelusium, nearly in longitude $32\frac{1}{2}°$ east of Greenwich; the other along the western bank of the most westerly branch, which fell into the sea near Canopus, about longitude $30\frac{1}{3}°$ east of Greenwich; and the Delta was included between these two.

The written history of Egypt is compiled from books in languages which were not the native speech of the land—Greek and Hebrew. The earliest Greek writer who gives any account of it—for the incidental allusions in the Homeric poems can scarcely be taken into account—is Herodotus, who compiled his history several years after Egypt had become a Persian province. In the Hebrew writings we have a few notices of independent Egypt, but the most of them relate to the foreign operations of the Egyptian monarchs. None of them furnish us with adequate notions of the civil history of Egypt; and of these notices the majority relate to the period when Egypt was at least in the process of being conquered. So old is this land, that it had been a mighty kingdom, and had become a tributary province before the commencement of what may properly be called civil history. Its written annals consist of incidental notices, subservient to telling the story of another state, in Hebrew, and the embodiment of old and perplexed traditions in Greek.

The earliest notice of the Egyptian state, that in the book of Genesis, represents it as monarchical. When Abraham first visited Egypt, about 1900 B.C., he found a Pharaoh ruling there. When Moses led the children of Israel out of



Egyptian Mummy.

Egypt, nearly 1500 years B.C., he left a Pharaoh reigning there. We have no grounds which decide that these Pharaohs reigned over the whole of the tribes that dwelt by the waters of the Nile; but it is evident that their sway was pretty extensive, and that their people had made considerable progress in the arts. Joseph sent up waggons for his father. The sending up of these vehicles seems to imply that they were not then to be found in the land of Canaan. The sudden transition of Jacob from incredulity to the conviction that his son Joseph must be alive in Egypt, upon seeing the waggons, strongly expresses the rarity of their appearance out of that land. Joseph was set in a chariot, so that men had learned in those early days to use vehicles in Egypt for pomp and luxury as well as convenience. The battle array in which Pharaoh set out to pursue the children of Israel, shows that chariots were used in his day to be applied in war as well as in peace. The number and array of his forces, too, bespeak skill in war and extended dominion. The method adopted by the mother of Moses to hide her son indicates that the art of navigating the river had not advanced beyond what we find at this day on the Euphrates, floating rafts of reeds or bulrushes daubed with pitch. The pitch with which the frail bark of the future legislator of the Hebrews was daubed, or *payed* (to use a technical phrase), implies perhaps two important facts; either (1) that the narrow valleys west

of the Nile were part of Pharaoh's realm, or (2) that the Egyptians could procure *asphaltum* from the Dead Sea. Already had the Egyptians learned their peculiar mode of preparing the bodies of the dead, in which pitch was required. We read in the time of Moses of priests and magicians, and that legislator was instructed in "all the learning of the Egyptians." The children of Israel acquired skill in Egypt, of which their shepherd fathers, when they went down into that land, knew nothing. Bezaleel and Aholiab were skilful artisans who could "grave on stones," one of the earliest arts that seems to have developed itself in Egypt. There can be no doubt that twenty centuries before the birth of Christ there were kings in the district of Egypt bordering upon Syria, and that sixteen centuries B.C. the Pharaohs of Mizraim held sway over a wide domain. Their people had also made considerable advances in the arts of agriculture, building, construction of vehicles, arms, and in priestcraft, which implied much other knowledge.

The Egyptians next appear in the Hebrew annals where Solomon is mentioned as having married a daughter of Pharaoh of Egypt. This alliance seems to have been contracted in the early days of his power, and he reigned forty years. Towards the close of Solomon's reign, Jeroboam, who afterwards ruled over the ten tribes, sought refuge from the anger of Solomon with Shishak, king of Egypt. Shishak (*Sheshouk*), four years after the death of Solomon, spoiled Jerusalem. It is highly probable that the wise king's father-in-law was the predecessor of Shishak. As the first of a new dynasty he would be jealous of his powerful Jewish neighbour, son-in-law of the monarch he had dethroned. Shelter to a fugitive of whom this neighbour was jealous would be readily given, especially as there was a prophecy that that fugitive should succeed to the greater part of Solomon's kingdom. He made war upon that neighbour's comparatively powerless son and successor, Rehoboam, against whom he marched with a mighty army with cavalry and war-chariots. Bocheris was deposed and killed by the Ethiopian invader Shabak, to whom Hoshea, king of Israel, sent presents. Shabak took part in the league against Sargon of Assyria, and while Israel was subdued, the Egyptian partner lost Lower Egypt and the Delta. His successor Sabatok entered into a fresh alliance with Hezekiah against Assyria. Sennacherib marched against them, but was overwhelmingly vanquished. Esarhaddon, who succeeded, bent his whole strength to the subjugation of Egypt, and, having conquered the land, parted it into satrapies and distributed the rulership to military governors. Egypt frequently revolted, but was as repeatedly reduced. At length, as Nineveh declined, Egypt put forth new efforts. Under Psammeticus, a native Egyptian prince who had married into the family of the reigning dynasty, a new policy was inaugurated. He opened Egypt to the Greeks, and their philosophers, with his leave, travelled and studied in the territories through which the Nile held its course. His son Neku II., the Pharaoh-nechoh of Scripture, was a brilliant warrior, and Josiah, king of Judah, was, in an invasion planned by him, overthrown and slain. His successors could not, however, hold the possessions he had secured. The Babylonian Nebuchadnezzar reconquered the territories he had won. Again the fortune of war was tried, and Amasis—with the aid of the Greeks—not only gained back the kingdom, but extended its boundaries. He acquired Cyprus, made alliance with Crœsus of Lydia against the Persians, and resolved on resisting the encroachments of that power. On his death Cambyses made a successful inroad, and in his most insulting mood triumphed over the weaker Psammenitus. Darius II. of Persia, more politic than his predecessor, introduced many beneficial changes into Egypt. Among other good works he constructed a canal between the Nile and the Red Sea. Several successive tributary kings held the sceptre, but insurrections, plots, and treasons grew rife. Agesilaus, king of Sparta, served under one of these kings, with his troops, as a mercenary soldier, and aided in the conspiracy which resulted in placing Nectanebes on the throne. This was the last of the native princes. Artaxerxes III. headed an expedition for the regaining of Egypt to the Persian monarchy, and was successful. Nectanebes fled to Ethiopia, and the dominion which had endured for thirty dynasties came to an end, and, as Ezekiel had foretold (xxx. 13), there was "no more a prince in the land of Egypt." Nor was there one until Alexander the Great appeared to drive the hordes of the Persian oppressors from the lands the Pharaohs had ruled.

It is not easy to determine the precise era of the Sesostris of Herodotus and Strabo. Coincidences show him, however, to have been called Sescasis by Diodorus, and Setharis by Manetho. He was chief of the nineteenth dynasty. Therefore considerably prior to the attack of Shishak upon Jerusalem, a king of Egypt was powerful enough to ravage—for it does not appear that he made any lasting conquest—the confines of Cilicia to the north, carrying home booty and captives. Collating backward the catalogue of Manetho, we find names which have been deciphered among the hieroglyphics; as, Minamon, the beloved of Ammon, of the eighteenth dynasty, and Thauthmesis, the founder of that dynasty. By the Egyptian chronology Thauthmesis must have commenced his reign B.C. 1874, *i.e.* he must have been contemporary with Abraham and Isaac. These dynasties are designated the Bubastic, the Diaspolita, &c., names derived from cities or districts in Egypt. They may have succeeded each other, according as the petty chiefs of any of the districts waxed sufficiently strong to throw off his subjection to the chief of some other districts who had previously lorded it over the others, and established himself in his stead. Thus the Pharaoh visited by Abraham, or his successor, being the first of a dynasty which took its designation from Diospolis or Thebes, must have reigned over Upper as well as Lower Egypt. The frontiers of the kingdom, even at that early period, were exactly where they were under Psammeticus, whose reign commenced 662 B.C. The haughty monarch whom Joseph served must have ruled a land equally extensive. The sacred annals narrate a very important change in the constitution of Egypt, occasioned by the famine revealed to Pharaoh in the dream interpreted by Joseph. These points of time bring the age of the great conqueror Sesostris to a period not very remote from that of Moses; and it increases our sense of the wonders achieved by that servant of God, when we reflect that he and his nomadic tribe were enabled to baffle the might of a monarch so powerful as the Pharaoh of Egypt must then have been.

Returning to Shishak, and tracing the catalogue of Egyptian sovereigns towards our own time, we come to the Ethiopian conquerors of Egypt, who reigned from 732 to 688 B.C. These cannot be viewed as kings of the Ethiopians—of all the Ethiopians. They were merely kings ruling over certain Ethiopian or Nubian tribes combined into one state on the Upper Nile, as the Ethiopians of the Egyptian union were on the Lower. Sesostris, at one time, turned his arms against the tribes living to the south of his dominions, and, favoured by their not being organized into one state, triumphed over them separately with ease. The lesson he taught these tribes was not lost upon them; and some centuries afterwards, a sufficient number of them, ranged under the banner of one king, retaliated upon Egypt, and subdued it. Egypt soon reasserted its independence, for in 662 B.C. we find a native prince again reigning from Syene to the sea. The subsequent history of independent Egypt was an incessant struggle for ascendency between the Egyptians and the Ethiopians of the Upper Nile. The exhaustion resulting from this protracted strife probably made Egypt fall so easily before the arms of Cambyses B.C. 525, when the sun of Egypt's independence set for ever. Egypt, after its conquest by Cambyses, remained a Persian province, with brief and unimportant exceptions, down to the overthrow of that empire. The land was horribly treated by the Persians, but it soon had a liberator in the person of Alexander the Great. The Macedonian conquest was a real benefit to the distracted country. Alexandria was built, Greek learning restored to Egypt a thousandfold what she had before received. It was next erected into an independent kingdom, with a Greek dynasty, by Ptolemy Soter, in the year B.C. 323, and continued in the hands of his descendants for three centuries. These Ptolemies were Macedonian Greeks, whose ancestor Lagus had followed Alexander

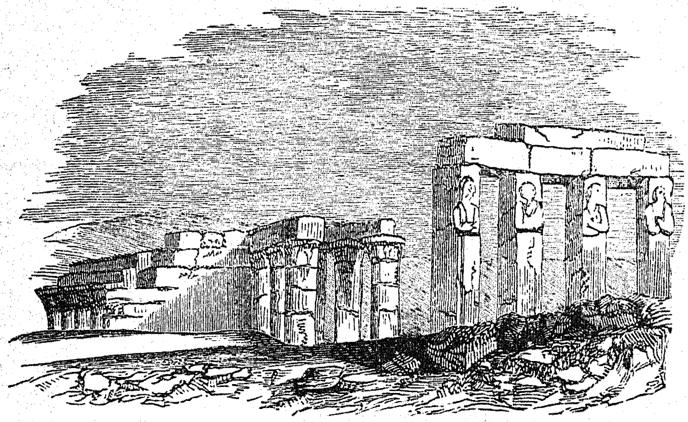
through all his campaigns. Ptolemy accompanied the Macedonians into Egypt, and had obtained the government on the division of the Macedonian Empire, which took place on the conqueror's death. He added to this satrapy Phœnicia and Cœle-Syria, and afterwards abdicated in favour of his youngest son. He is said to have founded the Museum and Library of Alexandria, was an able ruler, a patron of learned men, and a historian of the wars of Alexander, his father's friend. Ptolemy Philadelphus engaged in many wars, made peace at length with Syria and with the Romans, encouraged learning, and was an able administrator. Under him the Septuagint version of the Scriptures was made. His eldest son and successor, Euergetes, invaded Syria, reduced Mesopotamia, Babylonia, Susiana, and some of the provinces of Upper India, and brought back with him the statues of the gods which Cambyses had carried away from the Egyptian temples. Philopator, his successor, sadly dimmed the fame of the Ptolemies. He began his reign with murder, continued it in luxury and vice, and shortened his life by his debauchery, leaving the kingdom to his son Epiphanes, a child of five years old. The kings of Macedonia and Syria made a league, and resolved to divide his dominions between them. The Romans interposed and commanded them to refrain from hostilities. Epiphanes married Cleopatra, daughter of Seleucus. The monarchy under him rapidly declined, and he was poisoned by his courtiers in his twenty-ninth year. His successor, Philometer, was also a child. His mother, Cleopatra, became regent, and made war against Syria. Antiochus defeated her army at Pelusium, advanced to Memphis, and seized the young king—through whom he hoped to rule Egypt at will. For a while he succeeded, but it being agreed that Philometer and his brother should rule together, Philometer escaped. Antiochus then assailed Alexandria, but was inhibited by the Romans. After a time the brothers disagreed, and Euergetes II. expelled Philometer from the capital. He betook himself to Rome, was well received there, pleaded his cause before the senate, who appointed deputies to reinstate him in the sovereignty. His Syrian relations occupied much of his attention. He was fairly successful as a governor, and died as the result of a fall from his horse just in the hour of victory over Alexander Balas. Euergetes II. (Psychon) slew his nephew, who as Eupator had been proclaimed as his father's successor, massacred many of his adherents, and reigned in his stead. He first married Cleopatra, his own sister and his brother's widow. Afterwards he divorced her and married her daughter, his niece. An insurrection against him succeeded, and he fled to Cyprus, and Cleopatra, his sister, was declared queen. A revolt against Cleopatra led to his restoration to the throne, which he occupied for twenty-nine years. He left his kingdom to be held jointly by Cleopatra and her son Soter II. (Lathyrus). After a conjoint rule of ten years, Cleopatra originated a rising against him, called his brother Alexander to be her colleague on the throne, and he abode in exile eighteen years. On Cleopatra's assassination and Alexander's expulsion, Lathyrus was recalled, and after quelling an insurrection in Thebes—which stood a three years' siege—he reigned in tranquillity. His successor, Alexander II., was assassinated shortly after his accession, and Dionysius Auletes (the Flute-player), the illegitimate son of Lathyrus, was proclaimed by the Alexandrians. He sought the aid of Rome to ratify his title, and, at a great expense, obtained it. He was subsequently ignominiously expelled. The Romans, through A. Gabienus, proconsul of Syria, restored him. After a reign of twenty-seven years he died, bequeathing his sceptre conjointly to Ptolemy his son and Cleopatra his daughter. After they had reigned together for three years, Pothinus, the prime minister, expelled Cleopatra, who took refuge in Syria, where she raised an army, and with it invaded Egypt. "Broad-fronted Cæsar," pursuing Pompey from Pharsalia's field, just at this juncture came to Egypt. She appealed to the lordly Roman for help. He was fascinated by her charms, thought her "a morsel fit for a monarch," and won by her wooing, pledged Rome's power to replace her on the throne. The young king's guardians opposed Cæsar's wish, and thus the Alexandrine War broke out. Cæsar captured Ptolemy; he, however, managed to escape. Putting himself at the head of his friends, he advanced against Cæsar, was defeated, and when endeavouring to escape was drowned in the Nile. Cæsar declared Ptolemy Auletes colleague in the sovereignty with Cleopatra, who, it would seem, carrying her son Cæsarion with her, followed the mighty Julius to Rome. On her return after the assassination of Cæsar, she put her brother to death and wore the crown alone. On Antony's becoming one of the triumvirs, he received Asia as his share of the Roman government, met Cleopatra in Cilicia, followed her, a love-captive, to Egypt; and this afforded Octavius Cæsar (Augustus) the opportunity of crushing his rival. At the sea-fight off Actium, Antony was defeated. He, with Cleopatra, fled to Alexandria, and there, under pressure of foes and the faithlessness of friends, Antony, having stabbed himself, died in Cleopatra's arms, and she put an end to her life by the poison of an asp. Thus ended the dynasty of the Ptolemies. Egypt was incorporated into the Roman Empire by Augustus B.C. 30. It remained a province of the Roman Empire down to the taking of Alexandria A.D. 640.

Under the empires of Assyria, Media, Persia, Greece, and Rome, the dominant power not only allowed the natives to retain their original mode of worship, but frequently—either out of superstition, or a politic desire to ingratiate itself with its subjects—bowed and worshipped along with them. The recorded exception to this rule, in the case of Egypt, is Cambyses; and his war with the shrines and idols of the land, although extensive and destructive in its effects, was attributed, even by his own followers, to madness. Many of the most costly structures of Egypt were probably reared during the period which intervenes between the conquest of Egypt by Cambyses and the establishment of Christianity in Alexandria as the dominant religion early in the second century.

Let us pause and look back. Our authority is a catalogue of Egyptian monarchs which an Egyptian priest professed to extract from the hieroglyphic records of his country. The progress made in hieroglyphic literature has enabled us to recognize many of these names, thus far corroborating the assertion of Manetho. Light is occasionally thrown upon this dry catalogue from the narratives of contemporary Hebrews, and of Greeks of a later age who busied themselves about antiquarian lore. It is not much that we can glean from such scanty sources. This, however, seems established with tolerable certainty, that from the beginning of the twentieth century down to 525 B.C. Egypt—that is, the valley of the Nile below the lower cataract—was organized into one state; that that state was monarchical; that it was (with a few brief intervals) independent of foreign domination; that its monarchs more than once led their subjects upon warlike excursions on a great scale and with success, although they left no permanent settlement behind them. These foreign wars seem to have been confined to Syria proper, the shores of the Red Sea, and the Upper Nile.

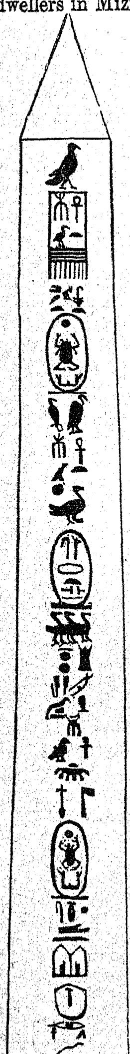
All the Egyptians were Ethiopians. They were, at least to a certain extent, self-governed, each district within itself. The peculiarity of their land—the periodical inundation of the Nile—was calculated to teach them the art and advantages of co-operation on a large scale at an earlier period than other nations. To render its fertilizing tendencies fully available, to prevent the damage its unwieldy kindness might do, works were required which could only be constructed by the joint labour of myriads. Hence the forgotten origin of the nilometers at Syene and Memphis. Some of the most obviously ancient structures of the Nile are the colossal causeways running from the river brink to the mountains. But of their erection, as of the digging of the first irrigating canal, tradition is silent. The constructing of such works required and familiarized men with organized exertion. Thus arose the central cities with their surrounding territories. And once united for such a purpose—which year after year brought them all together just at the moment when the swelling of the river left them for a time in search of pleasure to fill up the hours of indolence—the idea of a central place of resort, where the labyrinth was afterwards reared, was most natural. There they spent the hours in feasting till the time of labour again returned. There the thoughtful endeavoured to lead their minds to a sense of

gratitude to the Great Invisible, and sought to impress opinions which might render men more amenable to authority. There the knotty points of law, which had puzzled the collective wisdom of a district, were submitted to the sages of assembled Egypt. Thus were the Ethiopians of Egypt, the dwellers in Mizraim, taught to feel that they were one.



Thebes.

Herodotus mentions the temple of Heliopolis as existing in his day, such as it had been left by the devastations of Cambyses—shorn of its splendour. He speaks similarly of Thebes; of Memphis with its adjacent pyramids; and of Lake Mœris, with the structures around it, as works of the old independent Egypt. Three or four hundred years later, Strabo, who visited the country, particularizes these very edifices as of most undoubted antiquity. Herodotus speaks of them as shattered by the frantic excesses of Cambyses; Strabo points to them as having sunk, since that time, by an insensible decay, while other temples and other cities were flourishing around them.



The Horus.
Living of Men.
Pharaoh.
Sun Presented to the World.
Lord of Upper and Lower Egypt.
The Living of Men.
Son of the Sun.
Usurtesen.
Lord of Spirits in Pone.
Ever-living.
Life of Men.
Resplendent Horus.
Good God.
Sun Presented to the World.
Who has begun the
Celebration of his two Assemblies
to his Creator.
Life-giver for ever.

Obelisk.

Heliopolis—in the vicinity of Cairo, at some distance from the eastern bank of the eastern branch of the Nile, and northward of the termination of the range of hills which from Syene bounds the valley of the Nile on the east—was adorned with some of the most splendid temples in Egypt. Of these scarcely a ruin remains on the site of their ancient splendour. Its priests were celebrated for their learning. Heliopolis was visited by strangers for the purpose of profiting by their instructions. The largest of its temples was adorned with an avenue of sphinxes, and with several obelisks.

An obelisk covered with hieroglyphics—a genuine remnant of the independent era of Egyptian history—is shown in the accompanying illustration. It is connected with the Usurtesens of the sixteenth dynasty. Being in the city of the sun, it is dedicated to Phré, the sun-god.

Athanasius calls the Coptic dialect spoken in Egypt below the Thebaid, and without the Delta, the Coptic of Mizr, and Mizraim is the Hebrew name for Egypt. The Egyptian city designated Heliopolis, in the Septuagint version of the prophet Jeremiah, is called On in the Hebrew; and Pharaoh is said, in the book of Genesis, to have given Joseph the daughter of the priest of On to wife.

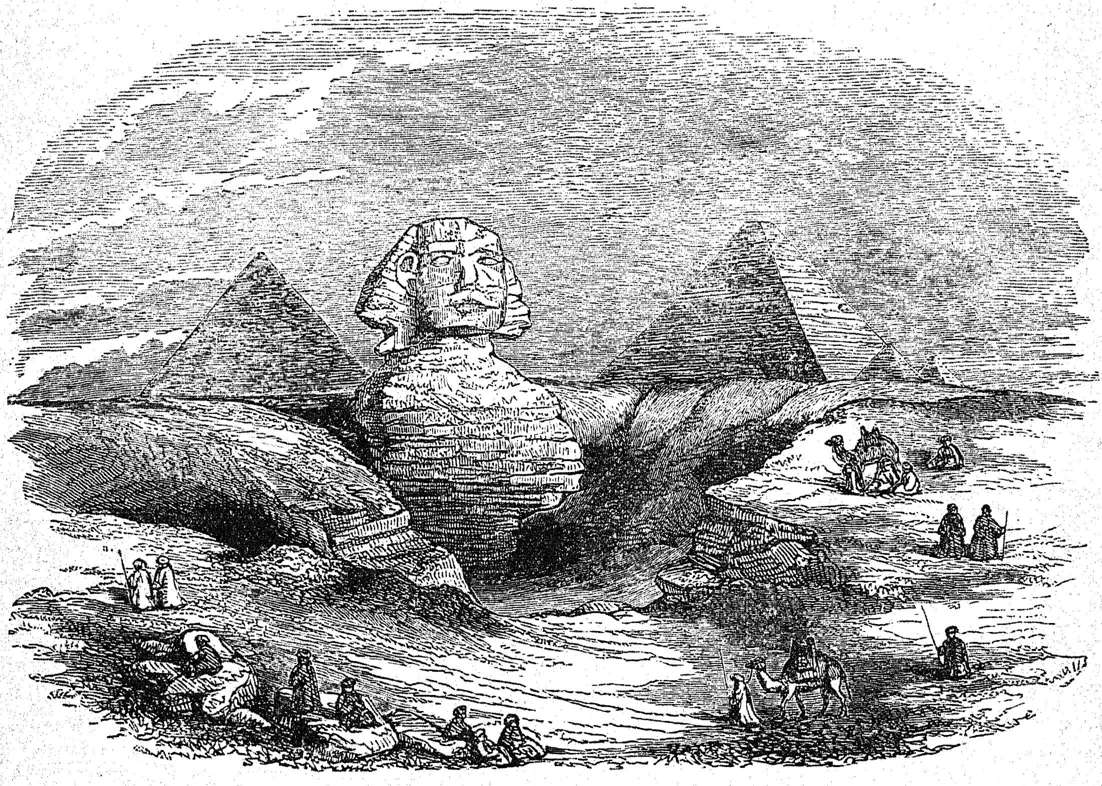
Memphis was situated 22½ miles above the apex of the Delta, on the western shore of the Nile. Here was a temple, dedicated to a divinity whom the Greeks called Hephaistion. Homer and Strabo mention the avenue of sphinxes which led to this as to every Egyptian temple. Both mention the pyramids. The pyramids are there, but we look in vain for the city of Memphis. Of it there is not left a trace. One solitary sphinx of the long colossal avenue remains. The desert sand, which has already overwhelmed On or Heliopolis, seems to gain year after year. The three pyramids of Djizzeh and the Sphinx are monuments of old independent Egypt.

In the uppermost of the two Arsinöitic nomes there is a gap in the range of mountains which runs along the western or African side of the valley of the Nile. Here we are told was a lake called Moeris, of prodigious extent, and, according to the Greek writers, artificial. Temples are mentioned as existing on its banks. But the most important structure described as existing there was the labyrinth. Herodotus speaks of it as one of the unquestionable relics of old Egypt. It was a structure of stone, supported by pillars and roofed with stone. It contained as many halls as there were districts in Egypt, all communicating with each other, and was the resort, at certain seasons for common purposes, of delegated authorities from all those districts.

The next locality to be mentioned is Thebes—the hundred-gated city—the fame of which had reached Greece even in the early days of the Homer of the Iliad. The city extended in length and breadth 10 miles either way, and it stood on both sides of the river. On one side of the Nile stood some temples, on the other the Memnon and the remains of two colossal statues, while the inhabitants dwelt around them in villages. The tombs of the kings in the mountain-glen behind the Memnonium are there to this day. These also are genuine relics of old Egypt. So are the temples of Luxor and Karnak on the eastern bank of the Nile, the Memnonium and the more than colossal statues near it, and the ruins of Edfu, the Apollonopolis Magna of the Greeks, standing on the western side of the river Nile, about 2 miles from the water's edge. The sculptures here are executed in the most perfect style of Egyptian art; and none of the remains in Egypt give a juster notion of the distribution of their temples.

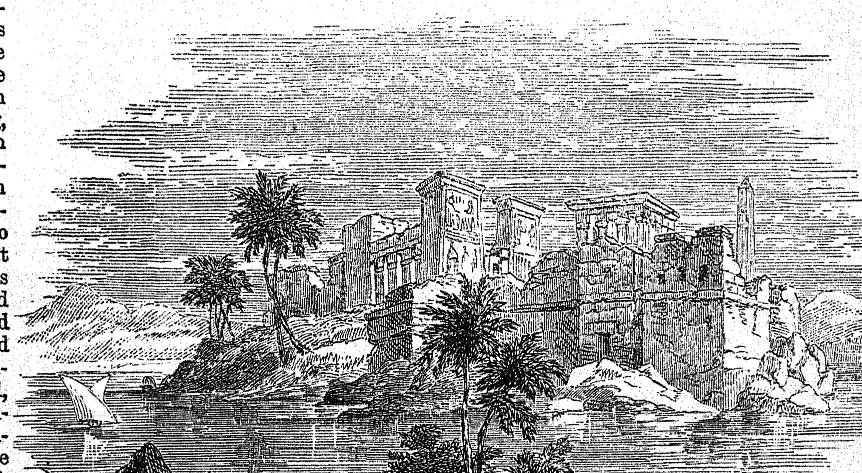
Towards Nubia, just before reaching the cataracts of the Nile, at a small island (called by the ancients Elephantina), where heaps of rubbish mark the site of the town, there are

the remains of two temples, covered, like most of the public buildings in Egypt, with hieroglyphics, but approaching in their form and plan to the earliest temples of Greece. Still more celebrated for its ruins is another small island, above the cataracts, and occupying almost the southern frontier of Egypt, where the river emerges from Nubia. Here we find the island of Philæ, about 6 miles to the south of Syene, and nearly 34 to the north of the Tropic of Cancer. The whole of this island, with an area of barely 900 yards in circumference and 100 in breadth, is covered with temples



Sphinx.

in the largest groups and highest state of preservation. This magnificent Iona of the "land of the Nile," which preserves these august remains hallowed by a "dim religious light," is of very remote antiquity. Those strange old structures stand in sublime grandeur, bearing, written around them, in the mysterious hieroglyphic tracery engraved on the walls, their own chronicles; yet in characters so ancient and abstruse, that only within recent years has the key been found to interpret the profound secrets of these sealed and silent symbols. Jeziret-el-birba, the Temple Island, is really an island of temples built of bright sandstone. The cliffs of the island itself are of dark granite, finely contrasting with the mass of ruined structures resting upon them. Nearly the whole island is cased with walls of hewn stone. It was believed to have been the burial-place of Osiris, and one of the magnificent temples with which the island is adorned is said to have been built by Isis in honour of her husband. The small temple of Isis is on the right, and southernmost of all is the great temple of Isis, in front of which are two colonnades, with as many obelisks and pylons,

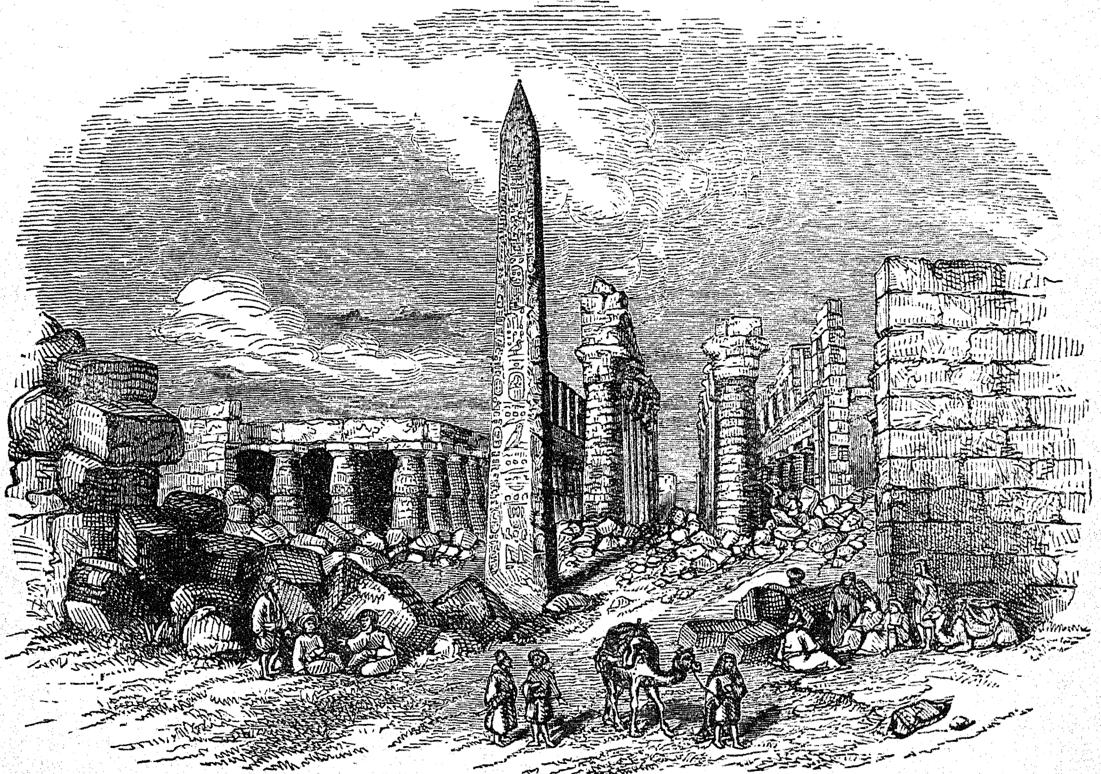


Philæ.

or portals, of huge dimensions. Near the small temple of Isis is an isolated, unfinished building, supposed to have been erected for the worship of the same deity. Near the water's

edge, at some distance from these temples, is a large hall, the walls of which are covered with sculptures relating to the death of Osiris; and on the left of the great temple of Isis there is an unfinished temple, and before it lay a small obelisk of granite, little injured, and covered with hieroglyphics, besides a Greek inscription. The latter bears to be a petition from the priests of Isis at Philæ, to Ptolemy Euergetes II., in 125 or 126 B.C., praying that monarch to release them from the exactions of the military officers and magistrates stationed in the Thebaid, and to allow them to erect an obelisk in commemoration of his beneficence in granting this request. The fact that the obelisk exists, not only shows that the request had been granted, but also that Ptolemy had his reward in the commemoration of his name in connection with this act of beneficence to a distant day. The obelisk at Heliopolis, the three pyramids at Djizzeh, and the neighbouring Sphinx, the remains in the Arsinöitic nome, and the temples, statues, and tombs at Thebes, these are the landmarks that rise in the almost trackless waste of Egyptian history to guide the inquirer's path. By their aid, with a critical investigation of what is written in Greek and Hebrew annals, aided by the light the recent discoveries in hieroglyphical literature throw upon the subject, and the Greek translations found in some of the papyri, we reconstruct in fancy the history of civil society as it existed in independent Egypt.

The age of the Pharaohs is the earliest discernible era of Egyptian civilization. All around was darkness and barbarism then. Upon the land of Egypt alone the day-star of human progress had begun to shine. How they came first to acknowledge a common head—by conquest or election —or how far his authority extended, it were vain to conjecture. The authority of Pharaoh beyond his own district might be very limited. It was easy, therefore, for the ambitious ruler of another, as that other grew in power, to subvert his ascendency.



Karnak.

One most important step in the progress of the monarchy is recorded in the Book of Genesis. On the occasion of the seven years' famine Joseph availed himself of the huge stores of grain in the royal granaries to purchase up the fee of the land from all except the priests. The effect of this was twofold :—(1) Pharaoh, now become a feudal monarch, was more powerful; (2) the priests—the only holders of allodial property—remained in worldly matters nearly on a footing of parity with the sovereign, while they possessed a yet stronger hold upon the superstitions of the people. Herodotus divides the Egyptians into priests, warriors, and husbandmen or artificers.

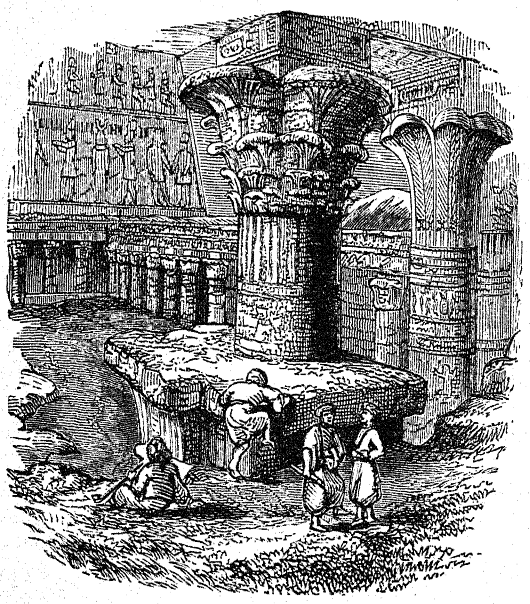
The power accumulated in the hands of the monarch explains his greater facilities for aggression; and the booty and slaves he carried home would increase his strength, and enable him to play freaks of power, the monuments of which still survive. With the exception of the Nilometer, the causeways, and canals of irrigation, all the works of ancient Egypt are either temples, or palaces, or sepulchral monuments, to feed the pride of kings. Whatever of art and science was known to the Egyptians was made tributary to the purposes of the king or the priest. The husbandman tilled the king's land for a portion of the harvest, or the priest's for what he could get. In their patient and unambitious toil, the hordes of slaves, the produce of external wars, co-operated, and thus the land was cultivated like a garden, and studded with those monuments which still excite our amazement. The sculptor and the painter worked under the direction of the priest, chiefly upon funeral and monumental, or sacrificial objects. The meanly servile condition of all who were not of royal blood, or priests, or of the warrior *caste*, facilitated the development of a multiplicity of *castes*, the son being mechanically bound to take to the business of the father. But man withered amid such institutions.

The priests knew the art of awing the vulgar mind. The obelisks are theirs. The columns of the temples of Luxor and Karnak are ruins in the first conception of what was afterwards idealized by the Greeks. The pyramids, with their substantial masonry, are theirs. These, in addition to the mere faculty of constructiveness, indicate a sense of the grandeur of colossal symmetry. Herodotus tells us that only two deities—Isis and Osiris—were worshipped by all the Egyptians: Strabo that the sacred bull might be seen in every city, but that there were only three deified bulls, those

of Memphis, Heliopater, and Thebes. The multiplicity of gods dates from the conquest of Egypt.

Among the priestly or learned class there arose land-measuring, sculpture, and architecture, the rudiments of law and of the art of writing. We possess papyri traced with characters of about the time of Manasseh in Israel, and long prior to the MSS. of any other nation that have come down to us.

Our purpose in endeavouring thus to trace the domestic institutions of the Egyptians, is to enable us to guess at their condition under the later monarchies. These governments were contented with using the royal tribute and the warlike



Columns at Edfu.

force of Egypt for their own purposes. They did not interfere with any of the other state arrangements. They left the laws and religion of the Egyptians much as they found them. Some monarchs sought to conciliate the priests, enhancing their wealth and the splendour of their rites. But the great community continued to dwindle. The traditions which Herodotus picked up, show us a nation fast sinking into the very senile helplessness of an effete race, and the records we have from the Romans show us the continuous decline of a people of an unenterprising and unprogressive character.

GEOGRAPHY.—CHAPTER VI.

THE GEOGRAPHY OF EUROPE (*continued*)—CLIMATE—NATURAL HISTORY—BOTANY—MINERALOGY—RACES OF MEN—RELIGION.

CLIMATE.—The northern countries of Europe lie, for the most part, above the fifty-fifth degree of N. lat.; here the climate is cold towards the north and temperate towards the south. The middle countries of Europe lie between the forty-fifth and the fifty-fifth degree of N. lat.; in this region the climate is temperate towards the north and warm towards the south. The southern countries of Europe lie to the south of the forty-fifth degree of N. lat.; and here the climate is warm towards the north and hot towards the south.

The climate of Europe, except towards the upper extremity of the continent, is more agreeable and better adapted to the development of the physical and intellectual faculties of man, than any of the other divisions of the globe. It is little exposed to those extremes of heat and cold which are so common in most other regions. This may be attributed to the circumstance of its being surrounded on almost every side by seas whose water is warmer than that of the ocean at large. The western coast of Europe, for example, is much warmer than the eastern coast of America under the same latitude—the difference of temperature in some parts being equal to 10 degrees of latitude.

In the northern countries of Europe only two seasons, summer and winter, occur—the summer lasting about three months, and the winter nearly nine months. Spring and autumn can scarcely be said to be known; they only comprehend a few days, and never more than two weeks. The vegetation is inconceivably rapid, and the heat of the summer very great. The winter is severe and boisterous, the ground being covered with an immense quantity of snow for a long period.

In the middle countries of Europe, the four seasons—spring, summer, autumn, and winter—are distinct, the one passing into the other by very gradual transitions. The extremes of heat and cold which are prevalent in the northern countries are here but little felt, the cold being much less severe in winter, and the heat less intense during the summer.

In the southern countries of Europe frost and snow are of rare occurrence; vegetation is therefore but little interrupted during winter. They are subject, however, to great and continued droughts for four, five, and, in some places, occasionally eight or nine months during summer, and to abundant rains during the last three months of the year.

NATURAL HISTORY: ANIMALS.—Owing to its more temperate and colder climate, and the extent to which its surface has been brought under the power of man, Europe contains far fewer wild animals than any of the other great divisions of the globe. The bear, the wolf, and the wild boar—once common in Britain and many other nations—have been in a great measure extirpated. The white bear is now confined to the polar regions; the brown bear, the wolf, and the wild boar to the high mountain ranges and the wooded districts of Europe. The elk and reindeer are found only in the extreme north. The red deer and roebuck exist in some of the central countries. The saiga, an antelope, roams the plains of Poland and Russia. The chamois or wild goat, and the ibex or bouquetin, are found in the Alpine regions of the south. The wild cat, a ferocious animal, is still common in many parts of Europe. The other wild animals are the lynx, a prowler in the south of Europe; the fox—in different varieties—distributed over the whole continent; and the common glutton or wolverine, a native of Denmark. Twenty-seven species of bats are reckoned to be European. The beaver, the porcupine, the flying squirrel, the hamster, and the marmot, are sparingly found in Europe; but rats and mice are very common. The two quadrupeds, ibex and musmon, are nearly extinct; the first supposed to be the original goat, the second the original sheep. The only quadrumanous animal in Europe is the Barbary ape, found on the Rock of Gibraltar.

The number of wild mammalia at present met with in Europe is only about 150 species; this includes twenty-eight of the whale and eight of the seal tribe. The number of land animals is thus reduced to 114, a very insignificant number compared with those found in the other great continents. Even of this small number only forty-four are now peculiar to Europe; the other seventy are found out of it, most of them being common also to Asia.

The domestic animals, the horse, ass, mule, ox, sheep, goat, dog, cat, &c., are too well known to require more than a simple mention.

BIRDS.—The birds of Europe are far more numerous than its mammalia. Upwards of 400 species are set down by naturalists as regular inhabitants, besides a number of occasional visitants. In the northern regions, where animal life of every kind is sparse, the species of birds are comparatively few, and most of them belong to the swimming and wading orders. The Arctic regions are peculiarly congenial to their subsistence and increase, and there they exist in immense numbers. Southward, where the climate is warmer, and a more luxurious vegetation is found, more abundant food exists for the support of the feathered tribes; accordingly, we find the species of birds living on insects and the produce of the earth very much increased in number and variety.

The birds of Europe, however, want the splendour and brilliancy of plumage which is such a remarkable peculiarity of the birds of tropical climates. In many instances this deficiency is more than counterbalanced by the sweetness of their song. The nightingale, the most melodious bird in the

world, though not exclusively confined to Europe, is common in England and many parts of the continent. The red grouse is regarded as the only bird peculiar to Great Britain.

As we approach the southern limit of the continent, we would expect to find the characters of the birds assimilated to those of Africa and Asia; and this is actually the case. On

the shores of the Mediterranean there is a reunion of the ornithology of Europe, Asia, and Africa. Beauty of plumage appears in the bright rosy wings of the wall-creeper in Italy, and the golden oriole in Sicily.

Reptiles.—There are but few reptiles in Europe, and of those few the greater part are harmless. The common viper is almost the only example of a venomous one. Many small lizards, and two species of turtle—the coriaccous and the loggerhead—are known. The strange amphibious reptile called the *Proteus anguinus* is found in the subterranean lakes, in the limestone caverns of Carniola.

Insects.—There are an immense number of annulose or articulate animals in this continent. Among the more troublesome varieties are the scorpion in Sicily, the gnat and the mosquito in Sweden, &c., during the summer months. The cantharis or blistering fly is native to the south of Europe.

Fish.—Many of the fish which frequent the shores of Europe are very important in a commercial and economic

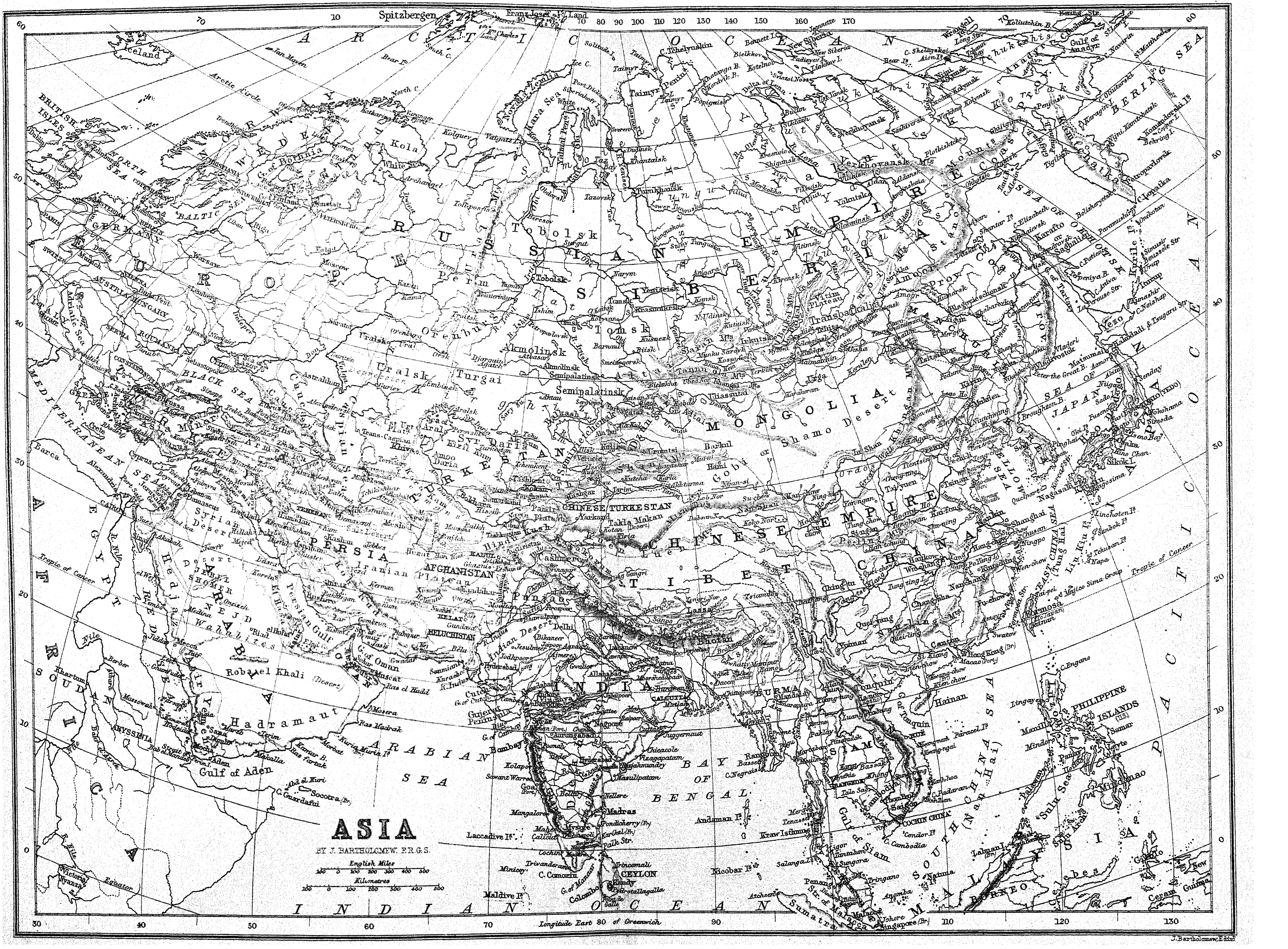
Olive Branches.

point of view. Their capture and preparation employ a great number of men, and they occupy a prominent place as articles of diet. The whale, the walrus, seal, &c., inhabit the northern seas; the anchovy and tunny abound in the Mediterranean; and the salmon, cod, ling, herring, haddock, &c., are plentiful in almost all the seas of Europe.

Botany of Europe.—If we divide the space included between the equator and north pole into seven botanical regions, according to the mean annual temperature, it will be found that the first or equatorial region is that of the spices; the second, of the sugar-cane and coffee-tree; the third, of the fig and the olive; the fourth, of the wine-grape; the fifth, of the oak and wheat; the sixth, of the fir, pine, and birch; and the seventh, of the alpine shrubs, lichens, and mosses. It must, however, be remembered, that these regions are not exclusively occupied by the vegetable productions we have enumerated; nor are these productions confined to these particular regions. They have usually a border territory which they occupy in common.

The warm regions in the south of Europe are occupied by the fig, the olive, the orange, maize, Guinea corn, the sugar-cane, rice, the American aloe, the caster-oil plant, the vine, the date, the pisang, and the prickly pear.

About parallel forty-three of N. lat. a marked change



J. Bartholomew, Edin[r]

in the vegetation occurs; the tropical forms of plants disappear or become uncommon. Still more to the north, the vine gives place to broad plains of wheat and other species of grain. There, too, we enter the fifth zone of vegetation—that of the oak and the wheat. Besides the oak, Europe has an abundance of elms, limes, ashes, alders, beeches, willows, and poplars, with a richness of grass and herbage quite unknown in the lands of olives, figs, and myrtles. The next region is that of the fir, the pine, and the birch. It produces also the principal portion of the food of the inhabitants—oats, barley, rye, and a few potatoes. Its fruits are apples, pears, nuts, gooseberries, strawberries, &c. In the frozen and polar region we have a very sparing vegetation, consisting chiefly of alpine shrubs, lichens, and mosses.

Minerals.—Gold, silver, platinum, and precious stones are found in various countries of Europe. Russia supplies the greater part of the gold, the platinum, and the precious stones, the remainder being furnished by Austria, Transylvania, and Saxony. Silver also occurs in small quantities in Hanover, Turkey, Prussia, England, France, &c.

Europe cannot vie with other regions in its produce of the precious metals; she possesses in abundance minerals far more useful to man, and much more contributory to wealth than gold, silver, and precious stones. Her iron, lead, copper, tin, quicksilver, coal, salt, &c., have done more to advance civilization than all the precious metals of the world put together.

Productions.—The following table gives a general view of the chief productions and exports of the different countries of Europe:—

Countries.	Productions and Exports.
Great Britain,	Cottons, woollens, linens, and jute; iron, steel, earthenware, glass, machinery, and coal.
France,	Wines, brandy, silk (raw and manufactured), woollens, leather, sugar, eggs.
Spain and Portugal,	Wines, raisins, and fruits; lead, copper, and iron ore.
Belgium and Holland,	Coal, iron, linen, lace, butter, cheese, corn, geneva, flax, and woollen manufacture.
Germany,	Textiles, iron, steel, metal goods, machinery, sugar, wines, coal, &c.
Denmark,	Corn, butter, and live stock.
Norway,	Timber, turpentine, fish, and ice.
Sweden,	Timber, iron, and corn.
Russia,	Tallow, corn, flax, hemp, flaxseed, timber, tar, bristles, and wool.
Austria,	Corn, flour, and wine.
Switzerland,	Cotton and silk manufactures, watches, straw hats, machinery.
Italy,	Silk (raw and manufactured), oils, spirits, lemons, oranges, wine, shumac, cheese, sulphur, and chemicals.
Turkey and Greece,	Corn, raisins, currants, raw silk, oil, wool and goats' hair, opium, Valonia currants.

Races of Men.—Man has been divided by ethnologists into four races or types:—(1) Caucasian, (2) Mongolian, (3) Ethiopian, and (4) Malay.

Nearly the whole of the inhabitants of Europe belong to the Caucasian variety; but along the borders of Asia, and towards the northern extremity of the continent, a few nations occur which belong to the Mongolian type; to these must be added the Magyars, who inhabit Hungary, in the centre of Europe.

If we adopt a division of the Caucasian race based on language, there will be three great branches and several smaller ones. The *first* great division comprehends those languages which are in a great degree derived from the Latin —the Italian, Spanish, Portuguese, and French. The *second* those of Teutonic origin, such as are spoken by the English, the greater part of the Scottish and Irish, the inhabitants of Iceland, Norway, Sweden, Denmark, Germany, and the Netherlands. The *third* is the Slavonian, spoken (in various dialects) in Bohemia, Silesia, Poland, Russia, Dalmatia, Croatia, Bosnia, Servia, and Bulgaria. Besides these three great branches, dialects of the ancient Celtic language are spoken in Scotland, Ireland, Isle of Man, Wales, and Brittany. Cornish Celtic now only exists in a few literary survivals, not as a spoken tongue.

Those Europeans who belong to the Mongolian race comprise—(1) the Magyars, who inhabit the greater part of Hungary; (2) the Lapps, the Finns, and the Samoyeds, who live near the Arctic circle; (3) the Inghers, the Esthonians, the Livonians, the Wogules, and the Wotyakes, who occupy different parts of the Russian Empire. A few Calmucks, Khirghises, and Baskirs inhabit the European side of the Ural Mountains. The Lithuanians and Courlanders speak languages peculiar to themselves. The south-east of

Circassian.

Europe is inhabited by Wallachians, Turks, Tartars, Albanians, and Greeks, who have all a distinct origin, and who speak peculiar languages.

The following is a table of the main divisions and general distribution of the Caucasian race over Europe:—

Celtic,	Spain, Portugal. France. Switzerland (*part of*). Belgium (*mixed*). Britain (*mixed*).
Teutonic,	*Scandinavian.* Norway, Sweden. Denmark, Faroe. Iceland, Orkney. *German.* Germany, Holland. Switzerland (*part of*). Britain (*mixed*). Belgium (*mixed*).
Slavonic,	Russia. Poland, Lithuania. Bohemia, Moravia. Servia, Bulgaria.
Mixed—Caucasian and Mongolian,	Finns, Lapps, Letts. Magyars. Turks. Basques.

Religion.—The Roman Catholic form of the Christian religion prevails in almost all the nations in the south and middle of Europe; the Protestant form in those of the north; and the Greek in those of the east. In some countries, as the German States, Belgium, &c., there is a mixture of Roman Catholics and Protestants. Mohammedanism is confined to Turkey and the extreme south of Russia.

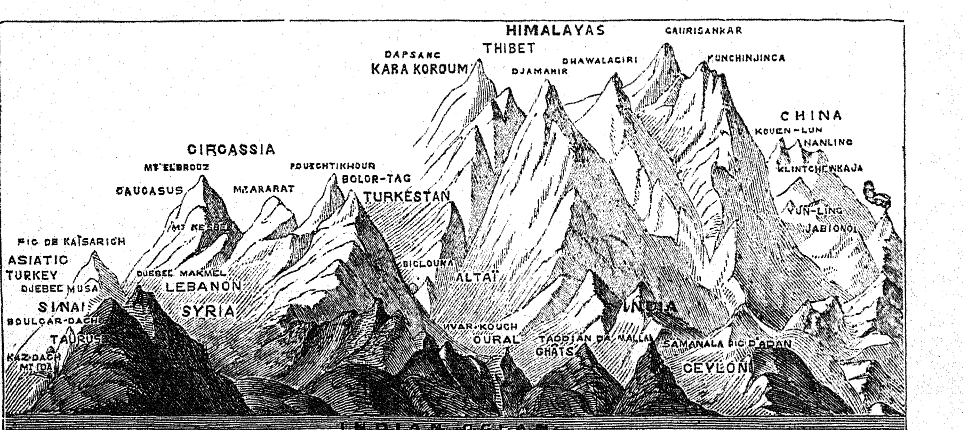
CHAPTER VII.

ASIA—PHYSICAL CHARACTERISTICS—CENTRAL AREA—MOUNTAIN RANGES—PENINSULAR PROJECTIONS—SEAS—ISLANDS —LAKES—COUNTRIES.

Far back, beyond the records of history, traditions abound regarding the infancy of mankind, and assign to Asia the credit of being the cradle of the human race. Prior to the birth of civilization, or the rise of the great empires of the

Orient, these traditions tell of times when the new-formed world was peopled with a few human beings, who dwelt, in the enjoyment of peace and plenty, in the Asian gardens and meadowlands, happy in their intercourse with one another and with the Divine powers who gave them life. Then came an era of moral catastrophes and miraculous changes, in which the earth was wasted and its inhabitants were scattered. Men wandered over the earth in unsettled masses, and toiled for subsistence of a precarious kind. As mankind multiplied, their difficulties increased; they separated into tribes, and aggregated into nations. Civilization constrained men, custom settled into law, and dominion became despotism. History's earliest glimpses of national life bring into view power, war, and superstition engaged in large enterprises and developing increasing activity. The field whereon, in life's morning dawn, when creation was young, men hunted in the forest, drove their herds to pasture, tilled the soil, and raised the city, was Asia—a name which comprehends all the countries lying to the east (1) of Europe and (2) of the northern part of Africa. This enormous mass of land is surrounded on three sides by the ocean, and it spreads out upon the surface of the sea along the line of the equator a train of insular dependencies. It presents a coastline of 33,000 miles, holds within its compass one-half of the population of the globe, and occupies a space of nearly five times the extent of Europe. Asia is separated from Africa by seas—except in one place where the narrow isthmus of Suez attaches that vast continental peninsula to the central mass of the Old World. It is connected with Europe by those low desert plains which margin the Caspian Sea on the north, and line the lower course of the Volga, and by the great mountain tract of the Urals. A trapezium, the four unequal angles of which might be laid on (1) the isthmus of Suez, (2) the northern reach of the Gulf of Tonquin, (3) East Cape on Behring Straits, and (4) the northern part of the peninsula of Zemlia, would inclose nearly four-fifths of the great Asiatic continent. The northern side of this figure, which may be regarded as the body of Asia, would extend to about 2700 miles, and be nearly parallel with the Arctic circle; the southern side, near the tropic of Cancer, would be almost double that length. Out from this central mass—as divers members—headlands and peninsulas project. The northern coast, though much indented, presents no peninsular forms of any great size. Towards the west is Asia Minor (or Anatolia)—that portion of Asia which, lying between the Black Sea and the Levant, and proceeding from Armenia and Mesopotamia on the east to the Archipelago and the Sea of Marmora on the west—has been a pathway of civilization and nations from Asia into Europe. On the south, three large peninsulas (unitedly almost equal in extent to Europe) stretch out into the seas of Arabia and India—viz. (1) Arabia, (2) India (within the Ganges), and (3) Transgangetic India, Indo-China (including Burmah, Siam, Tonquin, Cochin-China, and Malacca). Towards America, the peninsulas of the Tchukchees, of Kamtchatka, and of Corea project, while (to use the words of Karl Ritter) "the curved arc of the coast of China forms a kind of peninsula," taking an eastward sweep. The entire superficial area of Asia is 20,000,000 square miles. Cape Romania, in Malacca, lat. 1° 20′ N., forms its southern point, and Cape Severo, in Siberia, 78° 20′ N., its northern extremity; Cape Baba, in Asia Minor, lon. 26° 4′ E., is its western outpost, and on the east, one of the headlands running into Behring Straits terminates in lon. 170° W.

The eastern coast of Asia is deeply indented by seas—Kamtchatka or Behring Sea, the Sea of Okhotsk, the Sea of Japan, the Yellow Sea, the Chinese Sea, &c.—and these are fringed by numerous groups of islands, of which the Kuriles, Saghalien, Japan islands, Formosa, may be noted. The south-east might almost be said to be connected with Australia by a bridge of island groups—the Philippines, Borneo, Sumatra, Java, Celebes, the Moluccas, New Guinea, Timor, and the group around the Sandalwood Isles. Taking into account not only its immense central mass untouched by any of the seas which bound its shores, but also its insular and peninsular members—so abundantly washed by various seas—Asia, as a whole, presents the most diversified horizontal surface, and the greatest contrasts of scene, climate, territory, hill, valley, river-course, sea, and land. But its vertical outline is also singularly varied, and differs largely from that of the other continents. Its entire interior rises high above



Mountains of Asia.

the sea, and this immense elevated mass is occupied throughout its greatest extent by table-lands and plateaus, intersected and traversed by many mountain ranges, which lift their peaks above those lofty terraces and esplanades which fill up its centre rather than diversify its extremities.

The chief central continental mass of Asia is characterized by being composed of one vast nuclear plateau, divided into two highlands, (1) Eastern or Tibetan, (2) Western or Iran Asia—differing in geometrical outline and in vertical elevation; the former rising from 4000 to 10,000 feet above the sea level, while the latter scarcely reaches 4000—the one more rugged and uneven than the other. These two plateau systems, stretching from the neighbourhood of the Black Sea and the Persian Gulf to the sea which washes the coasts of Corea, measure a length of 5500 miles. In breadth they vary considerably, being, about Beloochistan, nearly 700 miles, while in the easterly parts of China and Tartary, they extend to 1800 or 2000 miles. Of these plateaus, Mount Elbourz, where it slopes down towards the Caspian, and the ranges of Caucasus and of Taurus may be regarded as the north-western extremity of the Iranese region. They proceed northwards by the ranges of the Altai Mountains into Siberia, and their north-eastern extremity is found among the Alpine heights of Daouria in Irkutsk. In the south-east they gradually descend towards the Gulf of Tonquin; in the south they slope down the Himalaya range and its branches, and pass off, in the west, into the ranges of Hindoo-Koosh as well as into the table-lands of the Anatolian peninsula. The whole system of highlands, though really forming one continuous range of elevations of the surface of the continent, contract

in breadth considerably in the central mountain-knot, where the ranges of Himalaya, Hindoo-Koosh, Beloor-Tagh, and Kuen-lin meet and are joined by a highland isthmus. As regards vertical outline, therefore, the ridges, peaks, table-lands, and plateaus of the Asiatic mass is not less indented and diversified than is the horizontal configuration of its coast-line. Upwards of forty peaks have been ascertained to range in their altitude from 23,000 to 29,000 feet above the level of the sea—Mount Gaurisankar or Everest, 29,002 feet, being the loftiest elevation on the earth. The terraces which connect the highlands and the lowlands descend gradually from the central mountain system in twelve great transitional steps. The valleys which they inclose form natural lines of communication, down which flow the water-supplies, along which the winds veer, change, and play. Flora and fauna, as well as races of men, under the natural influences of these differences, take peculiar characteristics, and thus this old historic continent is multifariously enriched with natural products, diversified scenery, and distinct civilizations and histories.

The six great prominent lowlands are (1) the Siberian, (2) the Chinese, (3) the Indo-Chinese, (4) the North-Indian, (5) the Syrian, and (6) Turkestan. These regions are all of vast extent and differ greatly in character, from waste and solitary expanses, or deserts sandy and gravelly—having a rainfall seldom and almost without water—to soil of the richest capacity, glorious with exuberant vegetation, visited by copious showers, and watered by rivers of mighty volume. Some districts are carpeted with long-lasting snow, and have their soil frozen down to immense depths; while others glow with the rarest profusion of variegated plant and flower life, and are luxurious with almost everlasting green. Splendid regions of fine scenery and fertility beyond description lie in the valley-lands, and every variety of earthly condition may be traced between these and "the abodes of snow," as the magnificent fortress-frontier of northern India, the Himalayas, is called. There glaciers abound, and these mighty peaks most truly "wear their caps of snow in very presence of the regal sun." These glaciers and snow-stores, in the high uplands, are the sources of the majestic rivers, which gather on the slopes, sweep down the gorges, and cleave their pathways to inland sea or shore-lapping ocean. The land-locked seas and lakes of Asia are remarkable for number, magnitude, and characteristics. Many of them—as the Caspian, Aral, Dead Sea, and Lake Balkash, are receptive seas, having feeders entering them, but no visible outlet for their waters, lying below the level of the ocean and subject to great evaporation. Nearly 1,200,000 square miles are drained by six considerable rivers, three of which—(not speaking of the European Volga), the Ural, the Terek, and Kur—find their way into the Caspian; two—the Amoo (Oxus or Jihoon), from Lake Sirikol, and Sir (Jaxartes), also rising in the Pamir table-land—flow into the Sea of Aral; and one—the Yarkand (Erghen)—empties itself into the comparatively small lake of Lob-nor, north of the great desert of Gobi. Another tract of land, at least half as large in superficial extent, possesses a multitude of small streams, which, after proceeding a short distance, get lost in small lakes or disappear among the sands of the thirsty deserts which they traverse. Binary rivers are characteristic of Asiatic hydrography. Of these we may mention the Ganges and the Brahmapootra, whose sources lie on opposite slopes of the Himalayas, converge and mingle their accumulated waters beside the same great delta at the head of the Bay of Bengal; the Indus and the Sutlej rise in the snowy mountains, flow westward through Tibet, and unite in the Punjaub; the Euphrates and the Tigris, in Western Asia, rise in the heart of the Armenian highlands, diverge to a considerable distance, force a way through the Taurus Mountains into the plains of Mesopotamia, gradually approach and form an actual confluence near the city of Bagdad, and run 150 miles as one stream into the Persian Gulf. Other conspicuous pairs of Asiatic rivers are the Hoang-ho and the Yang-tze-Kiang, whose sources lie near together, whose channels separate 1000 miles from each other, yet whose debouchures are not 100 miles apart; the Irrawaddy and Salwen, the Meiman and Cambodia.

The flora of Asia is usually systematized under seven divisions, including the following regions:—(1) Siberian, (2) Tartarian, (3) Cashmerian, (4) Syrian, (5) Himalayan, (6) Indian, and (7) Malayan. These districts are regarded as presenting well-marked differences arising from the widely diverse climatic conditions exhibited in this continent. The zoology of Asia is in extent and variety greater than that of any other region of the globe. It contains the greater portion of those animals by whose aid man tills the ground, extends his power, transports goods, and from which he derives food and raiment. The elephant, camel, dromedary, horse, ox, ass, goat, sheep, hog, dog, cat, &c., appear to be of Asiatic origin. Asiatic mineralogy is specially varied—gold, silver, copper, lead, iron, tin, zinc, quicksilver, &c.; precious stones of the more costly kinds, particularly diamonds, sapphires, topazes, &c.; pottery clays, coal, salt, &c., are found and used in many districts. The geological, atmospherical, and climatic phenomena which Asia presents to the scientist, are not less numerous than the races and religions which it brings under the notice of physiologists, philanthropists, philologists, and philosophical theologians. The theatre of human societies and diverse nationalities which it exhibits in actual operation supplies the student of life and politics with matter for interesting speculation. Contrast and isolation of races and products distinguishes Eastern from Western Asia—the Asia of historic effectiveness and the mother of civilization. In its great plains nations were founded, by the banks of its streams civilization prospered. Thought, imagination, industry, social subordination, and moral investigation arose in Asia, and gave to humanity the day-dawn of mental, moral, and industrial improvement.

Countries.—The principal countries of Asia are enumerated in the following table, with their area and population, but in most instances these elements are to be regarded merely as approximations:—

	Area in Square Miles.	Population.	Capitals or Chief Towns.
Russian Asia—Siberia and Transcaucasia,	5,000,000	15,000,000	Tobolsk, Tiflis.
Russian Turkestan (Central Asia), comprising Bokhara, Khokan, Khiva, Khirghis Territory,	1,550,000	7,750,000	Bokhara, Khiva.
Ottoman Asia—Asia Minor, Turkish Armenia and Kurdistan, Mesopotamia and Babylonia, Syria and Palestine,	500,000	16,000,000	Smyrna, Aleppo, Damascus.
Arabia,	1,200,000	8,000,000	Mecca.
Persia or Iran,	648,000	9,000,000	Teheran.
Afghanistan, Kafiristan,	220,000	5,000,000	Cabul.
India—British, Protected, and Independent States,	1,600,000	300,000,000	Calcutta.
Further India—Siam, French and British Possessions, &c.,	600,000	30,000,000	Bangkok.
Chinese Empire, comprising China Proper, Manchuria, Mongolia, Tibet, and Chinese Turkestan,	4,500,000	400,000,000	Pekin.
Korea,	82,000	8,000,000	Seoul.
Japanese Empire,	160,000	46,500,000	Tokyo.
Insular Asia—Sundas, Moluccas, Philippine and Sulu Islands, &c.,	786,500	34,500	Batavia, Manila.

THE FRENCH LANGUAGE.—CHAPTER VIII.

VERBS—THEIR NATURE AND KINDS—VOICE, MOOD, TENSE, NUMBER, AND PERSON.

In all languages the word which is most complex in its form, varied in its meaning, and most difficult to be mastered is the verb. Its functions are intricate and perplexing, and the conjugation of a verb is always felt to be an achievement when studying a foreign tongue. Its very name implies its special importance among words, as the word on which the structure of a sentence depends, and therefore the word over which it is most essential to acquire mastery. The variations for voice, mood, tense, number, and person; the differences in the mode of developing their peculiar conjugations; and the numerous irregularities of etymology, composition, and usage which occur in practice—complicate the study of them, even when the greatest care has been taken to ascertain their several points of resemblance and the analogies by which they may be related to each other in the memory. Of course careful classification and intelligent comparison of the structure, arrangement, and analogies of language contribute greatly to the facility with which a knowledge of the uses of verbs, in all their varieties, may be attained.

The verb is the animating principle of speech. No collocation of words can make a statement until a verb has conferred upon them the vital essence of expressiveness. It is the soul of the sentence. Its functions are to express the state, condition, or active powers of things and beings, the operations they perform, the influences they exert, or the impressions they communicate and receive; giving in the same word indications of the time of the action or state of the person or thing acting or existing, the number to whom it refers, the mood or manner of the work, and the originating conditions of the states or actions expressed by it. Considering the amount of ingenuity implied in the investing of one word with such extensive and various duties as the indication of all these circumstances, over and above that of the chief meaning of the verb itself, it is scarcely to be wondered at that difficulty should be felt in mastering the verbs of any language. And yet, as no proposition can be framed without the aid of a verb, no adequate and accurate communication of thought, feeling, or fact from one mind to another can be made without a ready and exact acquaintance with all the variations which verbs undergo.

One can easily see that it is of great importance to indicate (1) whether an act is *performed* or *endured*, that is, whether the agent is *active* or *passive*—in what *voice* he speaks; (2) whether the act or state is spoken of either as a certainty, with deliberation and confidence; or as a possibility; or as a wish, with doubt or hesitation regarding power or opportunity; or as an independent act or state, having no reference whatever to preceding or surrounding conditions; or as dependent so far that unless something else occurs or is likely to occur this cannot or will not be done; or as a command more or less imperatively imposed on those to whom it is addressed, according to their relation to the speaker—*i.e.* the *mood* which regulates the speaker's use of the verb; (3) whether the state or act is *past*, *present*, or *to come*, and the several relations in time (*tense*) which they bear to one another; (4) whether one or more in *number* are involved in the act or state; and (5) whether the persons interested are speaking, spoken to, or spoken about when the verb is being used.

When all the various forms which a verb undergoes for the purpose of indicating at once all these special requirements are arranged together, in regular and continuous order, properly distinguished from each other, and placed before the mind at one view, the verb is said to be *conjugated*, and the extended orderly presentation of these forms in this manner constitutes a *paradigm*—an exhibited example, a model. In the French language it is necessary to present four models of regular conjugations, in addition to which there are certain verbs which, because they do not in some points follow the model, are called *irregular;* and there are also two special verbs, generally named *auxiliary* or helping verbs, which, on account of their peculiar usefulness and necessity, require particular attention, and must have their specialties carefully exhibited.

Before doing this, however, it will be advisable to define with greater precision some of those technical words which grammarians employ, and which, from their peculiar use, are apt to puzzle and perplex the learner.

I. Voice.—This word is employed figuratively: the verb is personified; it is supposed to be endued with the power of speech, and a voice is given to it, by which it indicates whether its subject thinks, feels, and acts, or is thought of, compelled to feel, and acted upon—*i.e.* whether it is *active* or *passive.* In active verbs the agent or doer of an action is expressed in the nominative case, whereas in passive verbs the person or thing upon whom an agent or doer operates is expressed in the nominative case.

II. Mood.—Every act or state may be presented to the mind from many points of view. These are called *moods.* Of these there are five: (1) Infinitive, expressing whatever is affirmed by the verb in an unlimited, indeterminate manner, without specification of person or number. Hence it requires to be joined to another word to form complete determinate sense; as *Etudier est la plus utile des occupations,* To study is the most useful of occupations. (2) Indicative, presenting the affirmation to the mind positively and as an actual fact. It is a direct statement; as *Je remplis mes devoirs,* I fulfil my duties; *Socrate était un grand philosophe,* Socrates was a great philosopher. (3) Conditional, being dependent on some conditional circumstance, act, or state for its performance; as *J'irais le voir s'il était là,* I would go to see him if he were there; *J'aurais écrit si vous m'aviez donné du papier,* I would have written if you had given me some paper. (4) Subjunctive, showing the action or state in an indirect, subordinate manner, as subjoined to and resulting from some prior consideration; as *Je désire que vous remplissiez vos devoirs,* I wish that you would fulfil your duties. (5) Imperative, expressing command, exhortation, entreaty, request regarding an act or state; as *Venez me voir demain,* Come to see me to-morrow; *Ecrivez cette lettre,* Write that letter.

III. Tense.—The precise point of time at which we speak is taken as the dividing point of the periods to which affirmations may refer. There are three principal tenses: (1) the present, (2) the past, (3) the future; and they serve to express whether the act or state spoken of (1) exists at the time of speaking, (2) existed prior to the time of speaking, or (3) will come into existence after the time of speaking. The actual present is so narrow a point that it cannot admit of division into time more or less present, and therefore there is only one present tense possible. But the past—all the time that has preceded the act of speaking—may be regarded as subdivisible, and hence in French we have (1) the *imperfect past,* used to indicate that the action or state was going on at some (undefined) past time. It may also indicate that the act or state was continuous, repeated, or habitual; as *Il était malade,* He was ill. (2) The *perfect past,* used in reference to states or actions in a definite period of time, the beginning and end of which are known, but which is now completely past and gone; as *J'allai l'année passée en France,* I went last year to France. (3) The *future tense* is used to denote an action which is intended or fixed to take place at a time yet to come; as *J'irai demain,* I shall go to-morrow. Sometimes the idea intended to be conveyed is more that of duty and obligation than of the futurity in which these must be fulfilled, and then the future indicative takes almost an imperative sense; as *Vous aimerez vos parents,* You shall love your parents; *Vous ne parlerez pas,* You shall not speak. (4) Besides these naturally fixed divisions of time, the mind inclines to make a more or less definite indication of the portion of time referred to in the act of thought; thus the *pluperfect tense* indicates not only that the action itself of which mention is made as past is completely past, but also implies that some other intervening action has taken place, and is also already past; as *J'avais pris mon parti avant de sortir,* I had formed my resolution before going out.

It may here be advantageously remarked that in studying the conjugations it is not advisable, though they are exhibited in the paradigms, to commit to memory the various forms of the compound tenses formed by the simple tenses of *avoir* and its participle *eu.* It is quite as easy to form or translate

these tenses by giving their usual meaning to the various parts of *avoir*, as it is to interpret the similar English phrases "I have had my letter written for some time;" "I would have had it long ago," &c.

IV. Number.—There are of course terminations to show the difference between singular and plural.

V. Person.—As has been explained under Pronoun, there are three persons in each number—first, second, and third; and the verb takes a specific form of termination to denote the three different persons in each number.

Besides the above each verb has also certain tenses called compound, because the auxiliary verbs *avoir* and *être* are used to assist in forming them. It is because they are used thus that these verbs are called auxiliary. *Avoir* is used to form the compound tenses of *être*.

In the following paradigms the student must carefully commit to memory the present, imperfect, perfect definite, and future of the indicative mood, the present conditional, the imperative mood, the present and imperfect of the subjunctive mood, and also the infinitive and participles. When he has done this with both verbs, if he will carefully examine the remaining (compound) tenses, he will find he can make them up out of the tenses he has already learned.

CONJUGATION OF THE AUXILIARY VERBS.

Primitive Parts.

Infinitive,	Avoir,	*to have.*	Etre,	*to be.*
Pres. participle,	Ayant,	*having.*	Étant,	*being.*
Past participle,	Eu,	*had.*	Été,	*been.*

Indicative Mood.

PRESENT TENSE.

S. 1. J'ai,	*I have*,	Je suis,	*I am.*
2. tu as,	*thou hast*,	tu es,	*thou art.*
3. il a,	*he has*,	il est,	*he is.*
P. 1. nous avons,	*we have*,	nous sommes,	*we are.*
2 vous avez,	*you have*,	vous êtes,	*you are.*
3. ils ont,	*they have*,	ils sont,	*they are.*

IMPERFECT OR PAST TENSE.

S. 1. J'avais,	*I had*,	J'étais,	*I was.*
2. tu avais,	*thou hadst*,	tu étais,	*thou wast.*
3. il avait,	*he had*,	il était,	*he was.*
P. 1. nous avions,	*we had*,	nous étions,	*we were.*
2. vous aviez,	*you had*,	vous étiez,	*you were.*
3. ils avaient,	*they had*,	ils étaient,	*they were.*

PERFECT DEFINITE TENSE.

S. 1. J'eus,	*I had*,	Je fus,	*I was.*
2. tu eus,	*thou hadst*,	tu fus,	*thou wast.*
3. il eut,	*he had*,	il fut,	*he was.*
P. 1. nous eûmes,	*we had*,	nous fûmes,	*we were.*
2. vous eûtes,	*you had*,	vous fûtes,	*you were.*
3. ils eurent,	*they had*,	ils furent,	*they were.*

PERFECT INDEFINITE TENSE.

S. 1. J'ai eu,	*I have*		J'ai été,	*I have been.*
2. tu as eu,	*thou hast*		tu as été,	*thou hast been.*
3. il a eu,	*he has*	*had,*	il a été,	*he has been.*
P. 1. nous avons eu,	*we have*		nous avons été,	*we have been.*
2. vous avez eu,	*you have*		vous avez été,	*you have been.*
3. ils ont eu,	*they have*		ils ont été,	*they have been.*

PERFECT OR PLUPERFECT TENSE.

S. 1. J'avais eu,	*I had*		J'avais été,	*I had been.*
2. tu avais eu,	*thou hadst*		tu avais été,	*thou hadst been.*
3. il avait eu,	*he had*	*had,*	il avait été,	*he had been.*
P. 1. nous avions eu,	*we had*		nous avions été,	*we had been.*
2. vous aviez eu,	*you had*		vous aviez été,	*you had been.*
3. ils avaient eu,	*they had*		ils avaient été,	*they had been.*

PERFECT OR PLUPERFECT DEFINITE TENSE.

S. 1. J'eus eu,	*I had*		J'eus été,	*I had been.*
2. tu eus eu,	*thou hadst*		tu eus été,	*thou hadst been.*
3. il eut eu,	*he had*	*had,*	il eut été,	*he had been.*
P. 1. nous eûmes eu,	*we had*		nous eûmes été,	*we had been.*
2. vous eûtes eu,	*you had*		vous eûtes été,	*you had been*
3. ils eurent eu,	*they had*		ils eurent été,	*they had been.*

FUTURE TENSE.

S. 1. J'aurai,	*I shall*		Je serai,	*I shall be.*
2. tu auras,	*thou shalt*		tu seras,	*thou shalt be.*
3. il aura,	*he shall*	*have,*	il sera,	*he shall be.*
P. 1. nous aurons,	*we shall*		nous serons,	*we shall be.*
2. vous aurez,	*you shall*		vous serez,	*you shall be.*
3. ils auront,	*they shall*		ils seront,	*they shall be.*

FUTURE PERFECT TENSE.

S. 1. J'aurai eu,	*I shall*		J'aurai été,	*I shall have*	
2. tu auras eu,	*thou shalt*		tu auras été,	*thou shalt have*	
3. il aura eu,	*he shall*	*have had,*	il aura été,	*he shall have*	*been.*
P. 1. nous aurons eu,	*we shall*		nous aurons été,	*we shall have*	
2. vous aurez eu,	*you shall*		vous aurez été,	*you shall have*	
3. ils auront eu,	*they shall*		ils auront été,	*they shall have*	

Conditional Mood.

PRESENT TENSE.

S. 1. J'aurais,	*I should*		Je serais,	*I should be.*
2. tu aurais,	*thou shouldst*		tu serais,	*thou shouldst be.*
3. il aurait,	*he should*	*have,*	il serait,	*he should be.*
P. 1. nous aurions,	*we should*		nous serions,	*we should be.*
2. vous auriez,	*you should*		vous seriez,	*you should be.*
3. ils auraient,	*they should*		ils seraient,	*they should be.*

PAST TENSE.

S. 1. J'aurais eu,	*I should*		J'aurais été,	*I should*	
2. tu aurais eu,	*thou shouldst*		tu aurais été,	*thou shouldst*	
3. il aurait eu,	*he should*	*have had,*	il aurait été,	*he should*	*have been.*
P. 1. nous aurions eu,	*we should*		nous aurions été,	*we should*	
2. vous auriez eu,	*you should*		vous auriez été,	*you should*	
3. ils auraient eu,	*they should*		ils auraient été,	*they should*	

SECOND PAST TENSE.

S. 1. J'eusse eu,	*I should*		J'eusse été,	*I should*	
2. tu eusses eu,	*thou shouldst*		tu eusses été,	*thou shouldst*	
3. il eût eu,	*he should*	*have had,*	il eût été,	*he should*	*have been.*
P. 1. nous eussions eu,	*we should*		nous eussions été,	*we should*	
2. vous eussiez eu,	*you should*		vous eussiez été,	*you should*	
3. ils eussent eu,	*they should*		ils eussent été,	*they should*	

Imperative Mood.

S. 2. Aie,	*have (thou)*,	Sois,	*be (thou).*
P. 1. ayons,*	*let us have*,	soyons,†	*let us be.*
2. ayez,	*have (you)*,	soyez,	*be (you).*

Subjunctive Mood.

PRESENT TENSE.

S. 1. Que‡ j'aie,	*that I may*		Que je sois,	*that I may be*,
2. que tu aies,	*that thou mayst*		que tu sois,	*that thou mayst be.*
3. qu'il ait,	*that he may*	*have,*	qu'il soit,	*that he may be.*
P. 1. que nous ayons,	*that we may*		que nous soyons,	*that we may be.*
2. que vous ayez,	*that you may*		que vous soyez,	*that you may be.*
3. qu'ils aient,	*that they may*		qu'ils soient,	*that they may be.*

IMPERFECT TENSE.

S. 1. Que j'eusse,	*that I might*		Que je fusse,	*that I might be.*
2. que tu eusses,	*that thou mightst*		que tu fusses,	*that thou mightst be.*
3. qu'il eût,	*that he might*		qu'il fût,	*that he might be.*
P. 1. que nous eussions,	*that we might*	*have,*	que nous fussions,	*that we might be.*
2. que vous eussiez,	*that you might*		que vous fussiez,	*that you might be.*
3. qu'ils eussent,	*that they might*		qu'ils fussent,	*that they might be.*

PERFECT TENSE.

S. 1. Que j'aie eu,	*that I may*		Que j'aie été,	*that I may*	
2. que tu aies eu,	*that thou mayst*		que tu aies été,	*that thou mayst*	
3. qu'il ait eu,	*that he may*		qu'il ait été,	*that he may*	
P. 1. que nous ayons eu,	*that we may*	*have had,*	que nous ayons été,	*that we may*	*have been.*
2. que vous ayez eu,	*that you may*		que vous ayez été,	*that you may*	
3. qu'ils aient eu,	*that they may*		qu'ils aient été,	*that they may*	

* Note the spelling of the diphthong—*ay* when the syllable after it is sounded, otherwise *ai*.

† Observe the spelling of the diphthong—*oy* when the syllable after it is sounded, otherwise *oi*.

‡ The conjunction *que* prefixed to the subjunctive mood is no part of the mood itself, but is merely placed there to mark that the subjunctive is always dependent.

PLUPERFECT TENSE.

S. 1. Que j'eusse eu, *that I might*	*have had.*	Que j'eusse été,	*that I might*	*have been.*
2. que tu eusses eu, *that thou mightst*		que tu eusses été,	*that thou mightst*	
3. qu'il eût eu, *that he might*		qu'il eût été,	*that he might*	
P. 1. que nous eussions eu, *that we might*		que nous eussions été,	*that we might*	
2. que vous eussiez eu, *that you might*		que vous eussiez été,	*that you might*	
3. qu'ils eussent eu, *that they might*		qu'ils eussent été,	*that they might*	

INFINITIVE MOOD.

PRESENT.

Avoir,	*to have.*	Etre,	*to be.*

PAST.

Avoir eu,	*to have had.*	Avoir été,	*to have been.*

PRESENT PARTICIPLE.

Ayant,	*having.*	Étant,	*being.*

PAST PARTICIPLE.

Eu,	*had.*	Été,	*been.*

PAST PARTICIPLE (COMPOUND).

Ayant eu,	*having had.*	Ayant été,	*having been.*

In English the verb *to be* is often used in such expressions as—I am having, I was having, &c.; it is never so used in French. The one form of the present tense of *avoir* is used both to express the meaning I have, I am having, and I do have. The case is different in the *past* tenses of French verbs. The *imperfect* conveys the idea of habit or continuance of action; thus *j'avais* means I had, I was having, I used to have, &c.; while the *perfect definite* expresses that the special action referred to was completed at the time specified: *il fut fusillé,* he was shot.

EXERCISE.—Conjugate the whole verb *avoir* (1) with a noun after it; as *J'ai une pomme, j'avais une pomme,* &c.; (2) with the pronouns *l'* (*le*), it, and *les*, them; as *Je l'ai,* I have it; *tu l'as, il l'a,* &c.; *je les aurai, tu les auras,* &c. Proceed to conjugate *avoir*, adding the following words, *une grammaire, un livre, un cheval, une lettre.* (3) Conjugate the whole verb *être* with the adjective *fatigué*, tired; *e.g. je suis fatigué, tu es fatigué, il est fatigué, nous sommes fatigués,* &c.

Avoir and *être* are conjugated negatively by placing *ne* before the verb and *pas* after it.

Mode of Conjugating the Auxiliary Verbs Negatively.

INFINITIVE MOOD.

Ne pas avoir,	*not to have.*	Ne pas être,	*not to be.*
Pres. participle, N'ayant pas,	*not having.*	N'étant pas,	*not being.*
		Ne pas été,	*not been.*

INDICATIVE MOOD.

PRESENT TENSE.

S. 1. Je n'ai pas,	*I have not,*	Je ne suis pas,	*I am not.*
2. tu n'as pas,	*thou hast not,*	tu n'es pas,	*thou art not.*
3. il n'a pas,	*he has not,*	il n'est pas,	*he is not.*
P. 1. nous n'avons pas,	*we have not,*	nous ne sommes pas,	*we are not.*
2. vous n'avez pas,	*you have not,*	vous n'êtes pas,	*you are not.*
3. ils n'ont pas,	*they have not,*	ils ne sont pas,	*they are not.*

IMPERFECT OR PAST TENSE.

S. 1. Je n'avais pas,	*I had not,*	Je n'étais pas,	*I was not.*
2. tu n'avais pas,	*thou hadst not,*	tu n'étais pas,	*thou wast not.*
3. il n'avait pas,	*he had not,*	il n'était pas,	*he was not.*
P. 1. nous n'avions pas,	*we had not,*	nous n'étions pas,	*we were not.*
2. vous n'aviez pas,	*you had not,*	vous n'étiez pas,	*you were not.*
3. ils n'avaient pas,	*they had not,*	ils n'étaient pas,	*they were not.*

PERFECT DEFINITE TENSE.

S. 1. Je n'eus pas,	*I had not,*	Je ne fus pas,	*I was not.*
2. tu n'eus pas,	*thou hadst not,*	tu ne fus pas,	*thou wast not.*
3. il n'eut pas,	*he had not,*	il ne fut pas,	*he was not.*
P. 1. nous n'eûmes pas,	*we had not,*	nous ne fûmes pas,	*we were not.*
2. vous n'eûtes pas,	*you had not,*	vous ne fûtes pas,	*you were not.*
3. ils n'eurent pas,	*they had not,*	ils ne furent pas,	*they were not.*

FUTURE TENSE.

S. 1. Je n'aurai pas,	*I shall* or *will not have,*	Je ne serai pas,	*I shall* or *will not be.*
2. tu n'auras pas,	*thou shalt* or *wilt not have,*	tu ne seras pas,	*thou shalt* or *wilt not be.*
3. il n'aura pas,	*he shall* or *will not have,*	il ne sera pas,	*he shall* or *will not be.*
P. 1. nous n'aurons pas,	*we shall* or *will not have,*	nous ne serons pas,	*we shall* or *will not be.*
2. vous n'aurez pas,	*you shall* or *will not have,*	vous ne serez pas,	*you shall* or *will not be.*
3. ils n'auront pas,	*they shall* or *will not have,*	ils ne seront pas,	*they shall* or *will not be.*

CONDITIONAL MOOD.

PRESENT TENSE.

S. 1. Je n'aurais pas,	*I should* or *would not have,*	Je ne serais pas,	*I should* or *would not be.*
2. tu n'aurais pas,	*thou shouldst* or *wouldst not have,*	tu ne serais pas,	*thou shouldst* or *wouldst not be.*
3. il n'aurait pas,	*he should* or *would not have,*	il ne serait pas,	*he should* or *would not be.*
P. 1. nous n'aurions pas,	*we should* or *would not have,*	nous ne serions pas,	*we should* or *would not be.*
2. vous n'auriez pas,	*you should* or *would not have,*	vous ne seriez pas,	*you should* or *would not be.*
3. ils n'auraient pas,	*they should* or *would not have,*	ils ne seraient pas,	*they should* or *would not be.*

SUBJUNCTIVE MOOD.

PRESENT TENSE.

S. 1. Que je n'aie pas,	*that I may not have,*	Que je ne sois pas,	*that I may not be.*
2. que tu n'aies pas,	*that thou mayst not have,*	que tu ne sois pas,	*that thou mayst not be.*
3. qu'il n'ait pas,	*that he may not have,*	qu'il ne soit pas,	*that he may not be.*
P. 1. que nous n'ayons pas,	*that we may not have,*	que nous ne soyons pas,	*that we may not be.*
2. que vous n'ayez pas,	*that you may not have,*	que vous ne soyez pas,	*that you may not be.*
3. qu'ils n'aient pas,	*that they may not have,*	qu'ils ne soient pas,	*that they may not be.*

IMPERFECT TENSE.

S. 1. Que je n'eusse pas,	*that I might not have,*	Que je ne fusse pas,	*that I might not be.*
2. que tu n'eusses pas,	*that thou mightst not have,*	que tu ne fusses pas,	*that thou mightst not be.*
3. qu'il n'eût pas,	*that he might not have,*	qu'il ne fût pas,	*that he might not be.*
P. 1. que nous n'eussions pas,	*that we might not have,*	que nous ne fussions pas,	*that we might not be.*
2. que vous n'eussiez pas,	*that you might not have,*	que vous ne fussiez pas,	*that you might not be.*
3. qu'ils n'eussent pas,	*that they might not have,*	qu'ils ne fussent pas,	*that they might not be.*

IMPERATIVE MOOD.

P. 1. N'ayons pas,	*let us not have,*	Ne soyons pas,	*let us not be.*
2. n'ayez pas,	*have not,*	ne soyez pas,	*be not.*

When these verbs are used interrogatively the pronoun comes *after* the verb, as in English: *Ai-je?* Have I? and when *a* comes before a vowel, *t* is put between them for euphony: *A-t-il?* Has he?

When the subject of the verb is a *noun* it *remains first* in the sentence, and the question is put thus: *Mon père a-t-il . . . ?* Has my father . . . ? (literally, My father has he . . . ?)

The following is an example of how these verbs are conjugated both negatively and interrogatively:—

N'ai-je pas?	*have I not?*	Ne suis-je pas?	*am I not?*
n'as-tu pas?	*hast thou not?*	n'es-tu pas?	*art thou not?*
n'a-t-il pas?	*has he not?*	n'est-il pas?	*is he not?*
n'a-t-elle pas?	*has she not?*	n'est-elle pas?	*is she not?*
mon père n'a-t-il pas?	*has not my father?*	mon père n'est-il pas?	*is not my father?*
ma mère n'a-t-elle pas?	*has not my mother?*	ma mère n'est-elle pas?	*is not my mother?*

De is used before the object of a negative verb, instead of *un, une, a,* or *du, de la, des,* some, any; as *Je n'ai pas de plume,* I have not a pen; *Je n'ai pas d'encre,* I have no (not any) ink.

Avoir is used instead of the English *to be* to express states of feeling; as *J'ai froid,* I am cold; *Elle a peur,* She is afraid.

Reflexive verbs take the auxiliary *être;* as *je me suis reposé,* I have rested; *je m'étais reposé,* I had rested.

Some neuter verbs take *avoir* and others *être* in their compound tenses. The former is used to mark the action; as *Il a passé en Amérique au mois d'Août,* He went to America in the month of August. *Etre* when used as an auxiliary expresses a state; as *Il est resté cinq ans en Espagne,* He has remained in Spain five years, *i.e.* his state was that of being a resident in Spain.

When such verbs can be used in an active sense they naturally take the verb *avoir;* as *Il a monté l'escalier,* He has gone upstairs; *Nous avons descendu la montagne,* We have come down the hill; *Il a passé la rivière,* He has crossed the river.

A few neuter verbs by a change in their auxiliary indicate a difference of meaning; thus *convenir* if used instead of *plaire,* to please, takes *avoir;* as *Cet homme ne m'a pas convenu,* That man has not pleased me. If used in the sense of to make an agreement it takes *être;* as *Nous en sommes convenus,* We have agreed about it.

The verbs *comparaître,* to appear, *déchoir,* to decay, *demeurer,* to remain, *expirer,* to expire, *rester,* to stay, and the like, the sense of which is capable of variation, also follow the same rule in taking *avoir* and *être.*

The following verbs, when they signify passing from one state to another, take the auxiliary *avoir:—*

contrevenir,	*to infringe.*	paraître,	*to appear.*
courir,	*to run.*	périr,	*to perish.*
croître,	*to grow.*	rajeunir,	*to grow young.*
dormir,	*to sleep.*	succomber,	*to succumb.*
échapper,	*to escape.*	survivre,	*to outlive.*
grandir,	*to grow tall.*	triompher,	*to triumph.*
languir,	*to languish.*	vieillir,	*to grow old.*
marcher,	*to walk.*	vivre,	*to live.*

The following twelve neuter verbs take the auxiliary *être* only, viz.:—*aller, arriver, décéder, échoir; éclore, entrer; mourir, naître, partir; sortir, tomber* (and *retomber*); *venir* (also *devenir, intervenir; parvenir, revenir, and survenir*); as *Il était entré dans la chambre,* He had entered the room.

It is idiomatic French—although *être* implies state and *aller* movement, progress, or tendency—to say *J'ai été, J'avais été,* for *Je suis allé, J'étais allé;* as *Il a été en Italie.* Where, however, the idea of motion is strongly implied *aller* must be used; as *Il y est allé en poste par Marseille,* He has gone thither in haste, by Marseilles.

Y avoir (which literally signifies "there to have") is very frequently used as an impersonal verb. As it is rather difficult to conjugate, owing to its having the particle *y,* there, and also because the verb "to have" is used in French instead of "to be" in English, we here conjugate it at length.

INFINITIVE MOOD.

PRESENT, ...	Y avoir,	*there to be.*
PAST, ...	Y avoir eu,	*there to have been.*

PARTICIPLES.

PRESENT, ...	Y ayant,	*there being.*
PAST, ...	Y ayant eu,	*there having been.*

INDICATIVE MOOD.

PRESENT, ...	Il y a,	*there is* or *are.*
PAST, ...	Il y a eu,	*there has* or *have been.*
IMPERFECT, . . .	Il y avait,	*there was* or *were.*
PLUPERFECT, . .	Il y avait eu,	*there had been.*
PAST DEFINITE, . .	Il y eut,	*there was* or *were.*
PAST ANTERIOR, .	Il y eut eu,	*there had been.*
FUTURE, ...	Il y aura,	*there will be.*
FUTURE ANTERIOR,	Il y aura eu,	*there will have been.*
IMPERATIVE MOOD,	Qu'il y ait,	*let there be.*

CONDITIONAL MOOD.

PRESENT, ...	Il y aurait,	*there would be,*
PAST, ...	Il y aurais eu,	*there would have been.*

SUBJUNCTIVE MOOD.

PRESENT OR FUTURE,	Qu'il y ait,	*that there may be.*
PAST, ...	Qu'il y ait eu,	*that there may have been.*
IMPERFECT, . . .	Qu'il y eût,	*that there might be.*
PLUPERFECT, . .	Qu'il y eût eu,	*that there might have been.*

Y avoir is chiefly used in speaking of (1) *quantity,* (2) *number,* (3) *time,* and (4) *distance;* as *Il y en a encore un peu,* There is still a little of it; *Il y a encore une demi-heure,* There is yet a half hour; *Y a-t-il de l'encre?* Is there any ink?

"There is" and "there are" are both translated by *il y a,* because in French impersonal verbs have no plural.

In every case *y* is placed immediately before the verb: *e.g.* (1) in the compound tenses—*il y avait eu, qu'il y eût eu,* &c.; (2) when the verb is used interrogatively—*y a-t-il?* (3) negatively—*il n'y a pas;* or (4) both—*n'y a-t-il pas?*

EXERCISES.

Carefully write out a translation of the following sentences, and then compare them with the French translation given below:—

I.

1. Fortune is fickle. 2. God is, was, and shall be. 3. Such was my opinion. 4. He was attacked there. 5. They were killed together. 6. We shall be at home. 7. That would be useless. 8. Thou hast been at (the) school. 9. Be honest: let us be just. 10. I think (crois)

that they may-be there. 11. I have (some) bread and you have (some) butter. 12. He had a fine house. 13. You were hungry and cold (had hunger and cold). 14. They will have two horses. 15. I would-be afraid (have fear) of such a man. 16. They would-have had more than that. 17. Let us have patience.

1. La fortune est inconstante. 2. Dieu est, fut, et sera. 3. Tel était mon opinion. 4. Il fut attaqué là. 5. Ils fûrent tués ensemble. 6. Nous serons chez nous. 7. Cela serait inutile. 8. Tu as été à l'école. 9. Sois probe: soyons justes. 10. Je crois qu'ils soient là. 11. J'ai du pain et vous avez du beurre. 12. Il avait une belle maison. 13. Vous eûtes faim et froid. 14. Ils auront deux chevaux. 15. J'aurais peur d'un tel homme. 16. Ils auraient eu plus que ça. 17. Ayons patience.

II.

1. He will not be content. 2. They were not in the garden. 3. It is possible that he may not be gone (parti). 4. There were many (maintes) people. 5. Will there not be more?

1. Il ne sera pas content. 2. Ils ne furent pas dans le jardin. 3. Il est possible qu'il ne soit pas parti. 4. Il y avait maintes personnes. 5. N'y aura-t-il pas davantage.

III.

1. Is he afraid? (has he fear?) 2. Is he at home? 3. Have you (some) potatoes? 4. Why have you said (dit) that? 5. Am I wrong? 6. Is fortune fickle? 7. Where was he attacked? 8. Was he not very tall? 9. Would you be satisfied?

1. A-t-il peur? 2. Est-il chez lui? 3. Avez-vous des pommes de terre? 4. Pourquoi avez-vous dit cela? 5. Ai-je tort? 6. La fortune est-elle inconstante? 7. Où fut-il attaqué? 8. N'était-il pas très grand? 9. Seriez-vous contents?

CONJUGATION OF REGULAR VERBS.

There are in French four Conjugations, each distinguished by the termination of the present of the infinitive:—

The First	ends in	*er*,	as parler,	*to speak.*
" Second	"	*ir*,	" finir,	*to finish.*
" Third	"	*oir*,	" recevoir,	*to receive.*
" Fourth	"	*re*,	" vendre,	*to sell.*

Every verb is formed of two parts: (1) the root, which is invariable; (2) the termination, which is variable. Thus, in the verb *parler*, *parl* is the invariable or radical part, *er* the variable one. The conjugation of a verb according to a given model consists in affixing the inflexions proper to a given verb to the root or invariable part of that verb.

(1) In the First Conjugation, which has the infinitive form in *er*, as *parl-er*, the

Present participle	is formed by changing *er*	into *ant*,	*parl-ant.*
Past participle	" " *er*	" *é*,	*parl-é.*
Present indicative	" " *er*	" *e*,	*je parl-e.*
Perfect indicative	" " *er*	" *ai*,	*je parl-ai.*

(2) In the Second Conjugation, ending in *ir*, as *fin-ir*, the

Present participle	is formed by changing *ir*	into *issant*,	*fin-issant.*
Past participle	" " *ir*	" *i*,	*fin-i.*
Present indicative	" " *ir*	" *is*,	*je fin-is.*
Perfect indicative	" " *ir*	" *is*,	*je fin-is.*

(3) In the Third Conjugation, ending in *evoir*, as *rec-evoir*, the

Present participle	is formed by changing *evoir*	into *evant*,	*rec-evant.*
Past participle	" " *evoir*	" *u*,	*reç-u.*
Present indicative	" " *evoir*	" *ois*,	*reç-ois.*
Perfect indicative	" " *evoir*	" *us*,	*reç-us.*

(4) In the Fourth Conjugation, ending in *re*, as *vend-re*, the

Present participle	is formed by changing *re*	into *ant*,	*vend-ant.*
Past participle	" " *re*	" *u*,	*vend-u.*
Present indicative	" " *re*	" *s*,	*vend-s.*
Perfect indicative	" " *re*	" *is*,	*vend-is.*

From the present infinitive are formed the future indicative and the present of the conditional, by changing the infinitive terminations into *rai* and *rais*:—

Parle-r,	je parle-rai,	je parle-rais.
Fini-r,	je fini-rai,	je fini-rais.
Recev-oir,	je recev-rai,	je recev-rais.
Vend-re,	je vend-rai,	je vend-rais.

From the present participle are formed:—

(1) The present of the indicative in its three persons plural, by changing *ant* into *ons, ez, ent*—

Parl-ant,	nous parl-ons,	vous parl-ez,	ils parl-ent.
Finiss-ant,	nous finiss-ons,	vous finiss-ez,	ils finiss-ent.
Recev-ant,	nous recev-ons,	vous recev-ez,	ils reçoivent.
Vend-ant,	nous vend-ons,	vous vend-ez,	ils vend-ent.

(2) The imperfect of the indicative and the present of the subjunctive, by changing *ant* into *ais* and *e*—

Parl-ant,	je parl-ais.	que je parl-e.
Finiss-ant,	je finiss-ais,	que je finiss-e.
Recev-ant,	je recev-ais,	que je reçoiv-e.
Vend-ant,	je vend-ais,	que je vend-e.

All the compound tenses are formed with the past participle by means of the auxiliary verbs *avoir* and *être;* as *j'ai parlé, il a parlé; j'avais reçu, tu seras reçu, &c.*

From the present of the indicative is formed the imperative, by suppressing the pronouns *je, nous, vous;* as *je parle, parle; nous finissons, finissons; vous recevez, recevez.*

From the past definite indicative is formed the imperfect of the subjunctive, by adding *se* to the second person of the singular:—

Tu aimas,	que j'aimas-se.
Tu finis,	que je finis-se.
Tu reçus,	que je reçus-se.
Tu vendis,	que je vendis-se.

NATURAL PHILOSOPHY.—CHAPTER X.

HYDRODYNAMICS—MOTION OF FLUIDS—TORRICELLI'S THEOREM—VELOCITY OF EFFLUX—DISCHARGE BY ORIFICE IN THIN PLATE—VENA CONTRACTA—DISCHARGE BY SHORT PIPES—FRICTION OF LONG PIPES—LOSS OF HEAD BY FRICTION, BY BENDS, AND BY CHANGE OF DIRECTION—FRICTION OF RUST IN PIPES—FOUNTAIN JETS—OBLIQUE JETS—VELOCITIES OF FALLING BODIES.

HYDRODYNAMICS treats of the laws which govern the motion of non-elastic fluids, with the resistances which they oppose to bodies moving in them. Very little appears to have been known to the ancients of the laws of the motions of fluids, for even towards the close of the sixteenth century the action of the common pump in raising water was not understood, and Galileo explained the fact on the supposition that an attraction existed between the bottom of the pump piston and the water. It was not until after Torricelli, about 1640, discovered that the rise of the water was owing to atmospheric pressure on the surface of the water in the well in which the pump is immersed, and had made numerous experiments upon the velocity with which a fluid escaped from a small hole at the side of a vessel, that any advancement took place in understanding the laws concerning the flow of water through orifices and short pipes. Newton, in his "Principia," sets forth a series of propositions concerning the motions of fluids, and investigates the resistance offered by fluids to bodies moving in them; and these investigations form the basis of our present knowledge. The further researches of Euler, Lagrange, Laplace, and other continental mathematicians, have since contributed greatly to establish the principles of hydrodynamics on an analytical basis, and the laws of the motions of fluids in canals and rivers have further been determined experimentally by the Abbé Bossut, in 1771, and the Chevalier du Buat, in 1786.

In investigating the circumstances attending the discharge of fluids through orifices, the fluid is supposed to be divided into an infinite number of indefinitely thin laminæ or strata perpendicular to the axis, S B, of the vessel in which it is contained (fig. 1, Plate VII.), and that in the descent of the fluid these laminæ always preserve their parallelism till they come near the orifice, when they assume the shape of a funnel, about which the fluid is quiescent. Let the vessel be either cylindrical or prismatic, in a vertical position, and have an orifice whose height is A B. If Q q, R r, be a vertical section through such a lamina, its area perpendicular to the axis being represented by a, and if a' be the area of the orifice A B; also if g express the force of gravity, h the height B S, and v the velocity of a particle of fluid at the bottom of the orifice; then the

NATURAL PHILOSOPHY.

PLATE VII.

HYDRODYNAMICS.

Fig. 1.

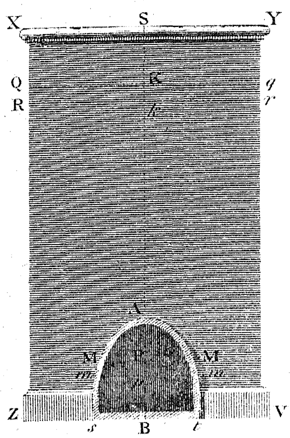


Fig. 3.

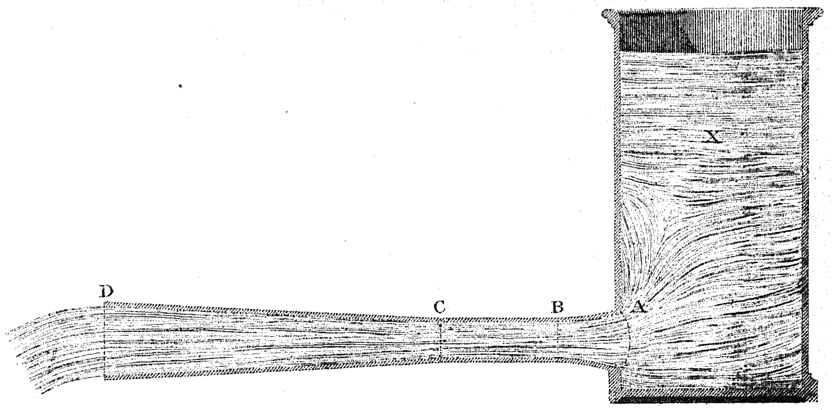


Fig. 2.

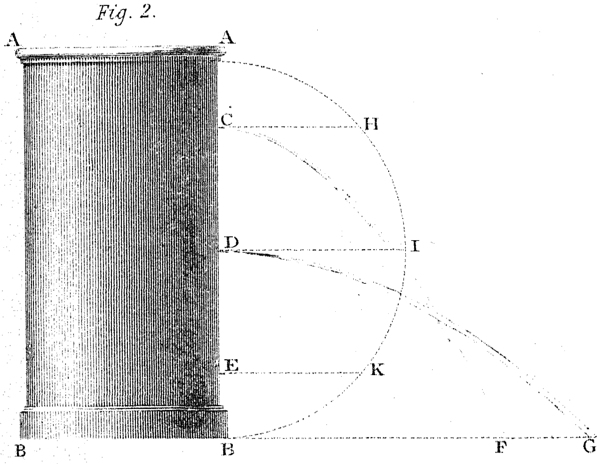


Fig. 4.

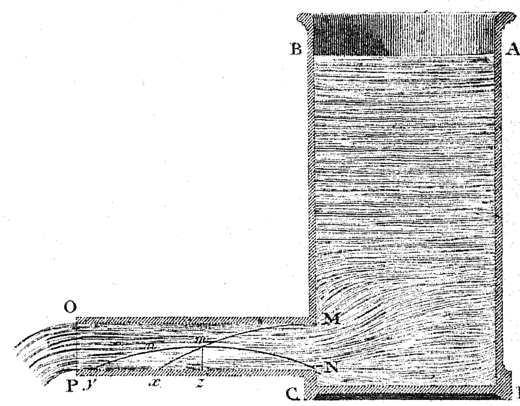


Fig. 7.

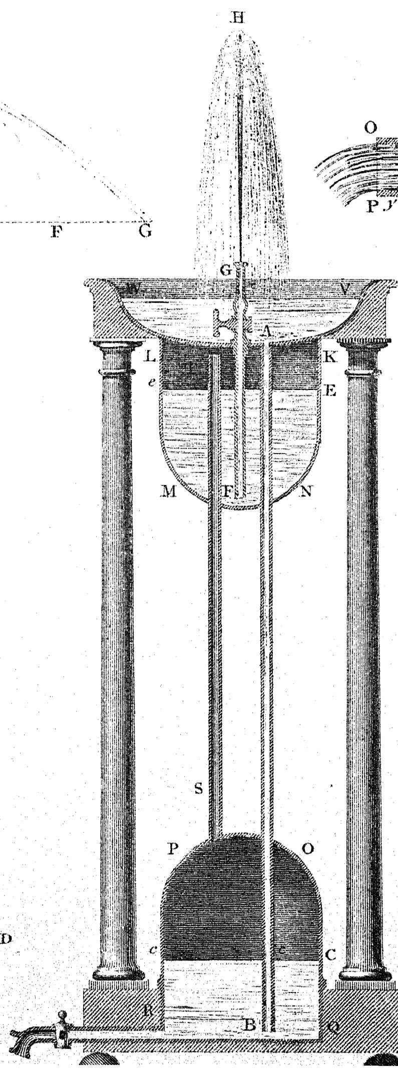


Fig. 6.

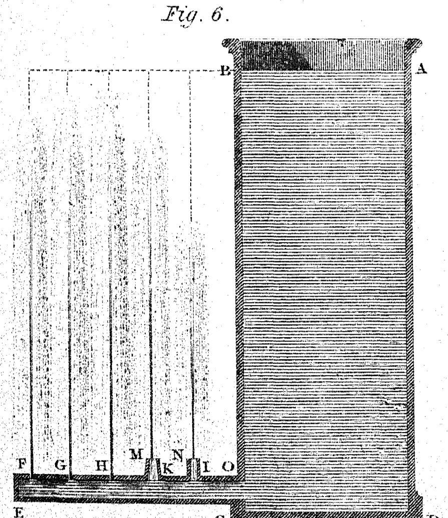
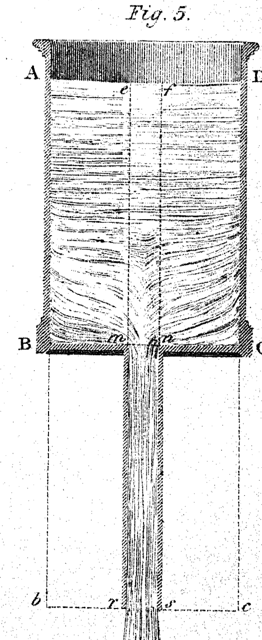


Fig. 5.



relation between the velocity v, and the height h, will be found from the equation $0=\frac{a'^2}{2a^2}v^2-gh+\frac{1}{2}v^2$; or considering the orifice as infinitely small, so that a' and the whole first term of the second member vanishes, then $0=-gh+\frac{1}{2}v^2$, or $v=\sqrt{2gh}$. But gh expresses the weight of a prism of fluid having unity for the area of its base, and whose height is h; and this is the pressure of the fluid against a small orifice at the bottom of the vessel; but while the height h is the same, the pressure is the same whatever be the position or inclination of the orifice; therefore $\sqrt{2gh}$ will express the velocity at the same depth, whether the orifice be at the bottom or side of the vessel. By the theory of forces, this is equal to the velocity that would be acquired by a body falling freely from the surface level of the liquid to the centre of the orifice from which it escapes. It would therefore follow from the above value of v, that the velocity of a fluid, spouting upwards through an orifice in a vessel, would cause it to ascend to the level of the upper surface of the liquid in the vessel were the resistance of the air removed. Torricelli's theorem may be therefore expressed thus:—*The velocity v is that which would be acquired by the mass m in falling freely from the surface level of the liquid to the centre of the orifice.* In this result each particle of the mass is supposed to move at right angles to the area of the orifice, and to escape into the air at a pressure equal to that at the surface level or *pressure height* under which the flow takes place.

The accuracy of the results formulated by Torricelli's theorem may be tested experimentally, for different liquids, by means of a vessel (fig. 2, Plate VII.) having apertures, C, D, E, in one of its sides, through any of which the water or other liquid it contains may escape. If the vessel A B be kept constantly full to the level A A, and one of these apertures be opened, as at C, the liquid will flow through it, and will descend in a curved path similar to that of a body projected horizontally from a certain height above the ground. If the distance B F, and likewise the distances B G and B F for the flow from the apertures D and E be observed, the accuracy of the theorem can be tested; for, let the height A E $=h$, then, according to the theorem, if v be the velocity of the fluid at E, $v=\sqrt{2gh}$, and the velocity will be uniform and horizontal.

Let t equal the time occupied by a particle in moving from E to F, then by the second law of motion t also equals the time occupied by a body falling freely from E to B, which is equal to the time of describing B F with the uniform velocity v; therefore B F $=tv$; also E B $=\frac{t^2g}{2}$; therefore E B $=\frac{(\text{B F})^2g}{2v^2}$, or $v=\text{B F}\times\sqrt{\frac{g}{2\,\text{E B}}}$. As therefore the distances B F and E B are known by observation, the value v so ascertained can be compared with that given by the theorem, $v=\sqrt{(2g\,.\,\text{A E})}$.

The quantity of fluid that can be discharged from an orifice in any given time, is equal to that of a column whose base is the area of the aperture, and its height the space described in that time by the velocity acquired by falling through the altitude of the fluid. And the quantity of discharge is the same, whatever be the figure of the aperture, if its area be the same.

Therefore, if h denote the altitude of the fluid, a the area of the orifice, and $g=16\frac{1}{12}$ feet, or 193 inches; then $2a\sqrt{hg}$ will be the quantity of fluid discharged in a second of time, or nearly $8\frac{1}{48}a\sqrt{h}$ cubic feet, when a and h are taken in feet. So let the height h be 25 inches, and the aperture a equal one square inch; then $2a\sqrt{hg}=2\sqrt{25\times193}=139$ cubic inches, which is the quantity of liquid discharged per second. Owing, however, to the resistance of the air, the resistance of the water against the sides of the orifice, and the oblique motion of the particles of the water in entering the aperture, it cannot be expected that experimental results exactly agree with theoretical calculation; and again, it is not merely the particles of liquid situated immediately in the column over the hole which enter it and issue forth, as if that column only were in motion; but also particles from all the surrounding parts of the fluid which are set in motion, so that the particles entering the orifice strike against each other, and impede one another's motion. From these causes only the particles in the centre of the aperture are discharged with the whole velocity due to the height of the fluid, the other particles towards the sides of the orifices pass out with diminished velocities; and the mean velocity of the liquid through the orifice becomes somewhat less than that of a single body only urged with the same pressure of the superincumbent column of the fluid. Experimental results show that the quantity of water discharged through apertures must be reduced by these causes, rather more than the fourth part when the orifice is small, or such as to make the mean velocity nearly equal to that in a body falling through one-half the height of the fluid above the aperture.

The following table gives the discharge of water by circular openings of various diameters, and under different *heads* or pressure height of water.

TABLE I.

Diam. Orifice in Inches.	Head of Water in Inches.												
	1	2	4	6	8	10	12	14	16	18	20	22	24
	Discharge through Orifice in Gallons per Minute.												
1	4·7	6·6	9·4	11·5	13·3	14·8	16·2	17·6	18·8	19·9	21	22	23
2	18·8	26·4	37·6	46·0	53·2	59·2	64·8	70·4	75·2	79·6	84	88	92
3	42·2	59·4	84·6	103	120	133	146	158	169	179	189	198	207
4	75·2	106	150	184	213	237	259	281	301	318	336	352	368
5	117	165	235	287	332	370	405	440	470	497	525	550	575
6	169	237	338	414	479	533	583	663	677	716	756	792	828
7	230	310	460	563	652	725	794	862	921	975	1029	1078	1127
8	301	422	601	736	851	947	1037	1126	1203	1273	1344	1408	1472
9	381	534	761	931	1077	1199	1312	1425	1523	1612	1701	1782	1863
10	470	660	940	1150	1330	1480	1620	1760	1880	1990	2100	2200	2300
12	676	952	1353	1656	1915	2134	2333	2534	2707	2865	3024	3170	3312
14	920	1241	1842	2254	2606	2901	3175	3450	3684	3900	4116	4312	4508
16	1203	1690	2406	2944	3405	3789	4147	4506	4813	5094	5376	5632	5888
18	1523	2138	3045	3726	4309	4795	5249	5702	6091	6447	6804	7128	7452
20	1880	2640	3760	4600	5320	5920	6480	7040	7520	7960	8400	8800	9200
22	2275	3194	4550	5566	6437	7163	7841	8518	9099	9632	10164	10640	11132
24	2704	3808	5414	6624	7660	8536	9332	10136	10829	11460	12096	12680	13248
velocity in feet per second.	2·32	3·275	4·63	5·67	6·55	7·32	8·03	8·67	9·27	9·83	10·36	10·87	11·35

When the discharging aperture is made in a thin plate, it has been found by experiment that the converging currents of water approaching the orifice cause a *contraction* in the issuing fluid, so that instead of a parallel or cylindrical

flow it becomes a stream of diminished breadth, assuming a conical form, the greatest contraction being at a point whose distance from the plate is half the diameter of the orifice, and its diameter ·784, that of the orifice being 1. The form of the curve in the stream, from the plate to the point of greatest contraction, is that of a circle whose radius is 1·22 times the diameter of the orifice. This contraction of the issuing stream is termed the *vena contracta.* When the height of a head of water in a vessel and the diameter of an orifice in its base or side are given, the discharge of water through the aperture—if of considerable thickness so as to form a short tube, not less in length than twice the diameter, or through a tube inserted in the orifice, its length not exceeding three or four times its diameter—is to that through the simple orifice nearly in the ratio of 12 to 11; and with a given diameter at its furthest extremity, the tube which in form coincides most nearly with the natural figure of the *vena contracta* gives the greatest discharge. This is shown in fig. 3, Plate VII., where A is the aperture, B the vena contracta or greatest contraction of the stream, and B C the length of the tube, some three or four times its diameter. The increase of discharge, in the ratio of 24 to 10, is shown at D. In fig. 4 the tube M N O P is attached horizontally to the reservoir A D C B. The tendency of the particles of fluid on issuing through the aperture, M N, would first be to describe the two parabolas, M m x, N n y. But the particles colliding with each other thus destroy the parabolas, and the fluid has then a constant tendency to contract. The length of the tube causes the liquid to accumulate, and it issues from the mouth O P in a full stream, but diminished in velocity. If a tube, $m\,n\,r\,s$, be inserted into a vessel, A B C D (fig. 5), the velocity of the discharging fluid through the aperture, $m\,n$, will be increased nearly in the sub-duplicate ratio of the length of the pipe.

The general rule for calculating the discharge of fluids by short tubes is $G=\sqrt{h}\times d^2\times 13$; where G is the number of gallons, h the height or head of water, and d the diameter of the pipe in inches, $h=\left(\frac{G}{d^2\times 13}\right)^2$, and $d=\left(\frac{G}{\sqrt{h}\times 13}\right)^{\frac{1}{2}}$.

The annexed table will be found a useful reference for the *actual discharge* by short pipes of various *diameters*, with square edges, and under different heads of water pressure, being eight-tenths of the theoretical discharge.

TABLE II.

Diameter in Inches.	Head of Water in Inches.												
	1	2	4	6	8	10	12	14	16	18	20	22	24
	Discharge in Gallons per Minute.												
1	3·76	5·28	7·52	9·2	10·6	11·8	13·0	14·1	15·0	15·9	16·8	17·6	18·4
2	15·04	21·12	30·01	36·8	42·6	47·4	51·8	56·3	60·2	63·7	67·2	70·4	73·6
3	33·08	47·05	67·07	82·4	96·0	106·4	116·8	126	135	143	151	158	166
4	60·02	84·08	120	147	170	189	207	225	241	254	269	282	294
5	93·06	132	188	230	266	296	324	352	376	398	420	440	460
6	135	190	270	331	382	426	466	530	542	573	605	634	662
7	194	248	368	450	522	580	636	689	737	780	823	862	902
8	241	338	481	589	681	758	829	901	962	1018	1075	1126	1178
9	305	427	609	745	863	959	1049	1140	1218	1290	1361	1426	1490
10	376	528	752	920	1064	1184	1296	1408	1504	1592	1680	1760	1840
12	541	762	1082	1325	1532	1707	1866	2027	2166	2292	2419	2536	2650
14	736	993	1474	1803	2085	2321	2540	2760	2947	3120	3293	3450	3606
16	962	1352	1925	2355	2724	3031	3318	3605	3850	4075	4301	4406	4710
18	1218	1710	2436	2981	3447	3836	4199	4562	4873	5158	5443	5702	5962
20	1504	2112	3008	3680	4256	4736	5184	5632	6016	6368	6720	7040	7360
22	1820	2552	3640	4452	5149	5730	6272	6814	7279	7705	8131	8518	8905
24	2163	3046	4331	5299	6128	6828	7465	8108	8663	9168	9676	10144	10598

Thus for a 9-inch pipe discharging 863 gallons per minute the table shows that the head of water necessary to generate the velocity at entry into the pipe is 8 inches. These calculations are irrespective of friction, which for pipes of so short a length may be considered as practically of no importance. Supposing it was required to determine the amount of head which will be required for the velocity at entry of the inlet end of a main from a reservoir, the table will give the head pressure required. When, however, as is usually the case, the pipe is of considerable length, the loss of head due to friction in the pipe must be allowed for; because in a long pipe there is not only the loss due to the velocity at entry, but there is also that due to the friction of the water against the sides of the pipe. Therefore the head pressure consumed is divided into two portions, one the amount due to the velocity of entry, irrespective of friction, and the other the amount of loss due to friction alone. To generate, therefore, the same velocity of flow in a long pipe as in a short tube, the head pressure for the long pipe must be the sum of that required for the velocity of entry and that requisite to compensate the friction of the long pipe. The loss of head pressure by friction may be obtained by the following rules:—
$G=\left(\frac{(3d)^5\times h}{l}\right)^{\frac{1}{2}}$ and $h=\frac{G^2\times l}{(3d)^5}$, when l is the length of the pipe in yards, h the head of water in feet, d the diameter of pipe in inches, and G gallons per minute; $d=\left(\frac{G^2\times l}{h}\right)^{\frac{1}{5}}\div 3$; $l=\frac{(3d)^5\times h}{G^2}$. The employment of logarithms will be found greatly to facilitate the working out of any required results from the formulæ. For instance, to find the discharge by a 7-inch pipe 3760 yards long, with a 42-feet head; then—

$$
\begin{array}{r}
7\times 3=21=1·32219 \\
5 \\
\hline
6·611095 \\
\times 42=1·623249 \\
\hline
8·234344 \\
\div 3760=3·575188 \\
\hline
2)4·659156 \\
\hline
2·329578=214 \text{ gallons per minute.}
\end{array}
$$

If it be required to find the head pressure necessary to discharge 300 gallons per minute by an 8-inch pipe 4000 yards long; then—

$$
\begin{array}{r}
300=2·477121 \\
2 \\
\hline
4·954242 \\
\times 4000=3·602060 \\
\hline
8·556302 \\
8\times 3=24=1·380211\times 5=6·901055 \\
\hline
1·655247=45·21 \text{ feet head.}
\end{array}
$$

Again, to find the diameter of pipe to discharge 120 gallons per minute with a 54 feet head, the length being 275 yards.

$$
\begin{array}{r}
120 = 2{\cdot}079181 \\
2 \\
\hline
4{\cdot}158362 \\
\times 275 = 2{\cdot}439332 \\
\hline
6{\cdot}597694 \\
\div 54 = 1{\cdot}732393 \\
\hline
5)\,4{\cdot}865301 \\
\hline
\end{array}
$$

$$\cdot973060 = 9{\cdot}39, \text{ and } \frac{9{\cdot}39}{3} = 3{\cdot}13 \text{ inches diameter.}$$

For instance, having the G, l, and d given, it is easy to find h. In the table opposite the given number of gallons, and under the given diameter, is found the head due to a length of one yard, and multiplying that number by the given length in yards gives the required head of water in feet. Again, to find d, having h, l, and G given: divide the given head of water in feet by the given length in yards, and the nearest number thereto in the table opposite the given number of gallons will be found under the required diameter. As it would occupy too much space to give more than the most important diameters and deliveries per minute, intermediate quantities and diameters must be calculated by the rules given. Again, to find G, having h, l, and d given: divide the given head of water in feet by the given length in yards, and the nearest number thereto in the table, under

TABLE III.

Gallons per Minute.	Diameter of Pipe in Inches.							
	2½	3	4	5	6	7	8	9
	Head of Water in Feet.							
5	·001053	·000423	·000100	...	...	...	...	...
10	·00421	·00169	·000401	·000131	·000052	·000024	·000012	·0000069
20	·01685	·00677	·00160	·000526	·000211	·000097	·000050	·0000278
30	·03792	·0152	·00361	·001185	·000476	·000220	·000113	·0000627
40	·06742	·0271	·00643	·002003	·000804	·000372	·000191	·0001060
50	·1053	·0423	·01004	·003292	·001323	·000612	·000314	·0001742
60	·1517	·0609	·01446	·004741	·001905	·000881	·000452	·0002569
70	·2064	·0830	·01969	·006453	·002593	·001200	·000615	·0003415
80	·2696	·1084	·02572	·008428	·003386	·001567	·000803	·0004460
90	·3413	·1372	·03255	·010667	·004286	·001983	·001017	·0005645
100	·421	·169	·0401	·01317	·005292	·00244	·001256	·00069
150	·948	·381	·0904	·02963	·011907	·00551	·002826	·00156
200	1·685	·677	·1607	·05268	·021168	·00979	·005024	·00278
250	2·633	1·058	·2511	·08231	·033075	·01530	·007850	·00435
300	3·792	1·524	·3617	·11853	·047628	·02204	·011304	·00627
350	5·162	2·075	·4923	·16133	·064827	·03000	·015386	·00853
400	6·742	2·710	·6430	·21072	·084672	·03918	·020096	·01115
450	8·53	3·43	·813	·2666	·10716	·04959	·025434	·01411
500	10·53	4·23	1·004	·3292	·13230	·06122	·031400	·01742
600	15·17	6·09	1·446	·4741	·19051	·08816	·045216	·02509
700	20·64	8·30	1·969	·6453	·25930	·12000	·061544	·03415
800	26·96	10·84	2·572	·8428	·33868	·15673	·080384	·04460
900	34·13	13·72	3·255	1·0667	·42865	·19836	·101736	·05645
1000	42·14	16·94	4·019	1·3170	·52920	·24490	·125600	·06970

TABLE III.—*Continued.*

Gallons per Minute.	Diameter of Pipe in Inches.												
	5	6	7	8	9	10	12	14	16	18	20	21	24
	Head of Water in Feet.												
2000	5·2	2·11	·97	·50	·27	·164	·066	·0306	·0156	·0087	·0051	·0040	·0020
3000	11·8	4·76	2·20	1·13	·62	·370	·148	·0688	·0353	·0196	·0115	·0090	·0046
4000	21·0	8·46	3·91	2·00	1·11	·658	·264	·122	·0627	·0348	·0205	·0161	·0082
5000	32·9	13·23	6·12	3·14	1·74	1·02	·413	·191	·0981	·0544	·0321	·0251	·0129
6000	47·4	19·05	8·81	4·52	2·50	1·48	·595	·275	·141	·0784	·0462	·0362	·0186
7000	64·5	25·93	12·00	6·15	3·41	2·01	·810	·374	·192	·107	·0630	·0493	·0253
8000	84·2	33·86	15·67	8·03	4·46	2·63	1·05	·489	·251	·139	·0823	·0644	·0330
9000	106·6	42·86	19·83	10·17	5·64	3·33	1·33	·619	·317	·176	·104	·0816	·0418
10,000	131·7	52·92	24·49	12·56	6·97	4·11	1·65	·765	·392	·217	·128	·100	·0516
20,000	526·8	211·68	97·96	50·24	27·88	16·46	6·61	3·06	1·56	·871	·514	·403	·206
30,000	...	...	...	...	...	...	...	6·88	3·53	1·96	1·15	·906	·465
40,000	...	...	...	...	...	...	...	12·24	6·27	3·48	2·05	1·61	·826
50,000	...	...	...	...	...	...	...	19·12	9 81	5·44	3·21	2·51	1·29
60,000	...	...	...	...	...	...	...	27·54	14·12	7·84	4·62	3·62	1·86
70,000	...	...	...	...	...	...	...	37·49	19·23	10·71	6·30	4·93	2·53
80,000	...	...	...	...	...	...	...	48·97	25·11	13·93	8·23	6·44	3·30
90,000	...	...	...	...	...	...	...	61·97	31·78	17·64	10·41	8·16	4·18
100,000	...	...	...	...	...	...	...	76·51	39·24	21·78	12·86	10·07	5·16

the given diameter, will be found opposite the required number of gallons. Further, to find l, having h, G, and d given: divide the given head by the head for one yard found in the table under the given diameter, and opposite the given number of gallons, and the result will be the required length. In order to facilitate the calculations for any intermediate numbers, it may be observed that the head varies as the square of the discharge, so that, for instance, ten times any given discharge will require 100 times the head, &c. Thus, with 100 gallons the table shows that a 5-inch pipe requires ·01317 foot head per yard; then with 1000 gallons the head would be $\cdot01317 \times 100 = 1\cdot317$ foot; and with 10 gallons $\frac{\cdot01317}{100} = \cdot0001317$ foot.

The application of this principle to any case in practice is very simple; suppose it is required to find the head for 35 gallons with a $2\frac{1}{2}$-inch pipe 650 yards long. Not finding 35 gallons in the table as given, take 350, the head for which is 5·162, therefore for 35 gallons it will be $\frac{5\cdot162}{100} = \cdot05162$. The head required therefore will be $\cdot05162 \times 650 = 33\cdot553$ feet.

To the head thus found by the rules given and the table must be added that due to the velocity of entry of the fluid into the orifice of the pipe. When the pipe is of the common form with square edges, as in fig. 4, Plate VII., Table II. gives the head for velocity direct. For very long pipes this is so small in proportion to the head due to friction, that in most cases it may be omitted. But when a pipe is very short, the head due to velocity may be much greater than the head due to friction. Let there be an 18-inch pipe 20 yards long, discharging 3000 gallons per minute. By Table III. (which gives the head of water *consumed by friction* with pipes one yard long) the friction is $\cdot0196 \times 20 = \cdot392$ foot; and the head due to velocity by Table II. is 6 inches or ·5 foot, being greater than the head due to friction; so that the total head is $\cdot392 + \cdot5 = \cdot892$ foot. The general law regarding the discharge of pipes may be given as follows:—*The discharge by any pipe, or series of pipes, is proportional to the square root of the head; and the head is proportional to the square of the discharge.* There is another source of loss of head in pipes, namely, by change of direction or bends. The following is the formula for calculating this loss:—

$$H = (\cdot131 + (1\cdot847 \times \left(\frac{r}{R}\right)^{\frac{7}{2}}) \times \frac{V^2 \times \phi}{960};$$

$$\text{and } V^2 = \frac{960 \times H}{\phi \times (\cdot131 + (1\cdot847 \times \left(\frac{r}{R}\right)^{\frac{7}{2}})}; \text{ in which}$$

H = the head due to change of direction, in inches.
r = radius of the bore of the pipe, in inches.
R = radius of the centre line of the bend, in inches.
ϕ = angle of bend, in degrees.
V = velocity of discharge, in feet per second.

If it is required to find the loss of head by a bend of 9 inches radius in a 6-inch pipe, discharging 800 gallons per minute, with an angle of 55°, a 6-inch pipe will contain roughly $\frac{6^2}{30} = 1\cdot2$ gallon per foot length, and the velocity of discharge will be $\frac{800}{1\cdot2 \times 60} = 11\cdot1$ feet per second. To find $\left(\frac{r}{R}\right)^{\frac{7}{2}}$, or in the present case $\left(\frac{3}{9}\right)^{\frac{7}{2}}$, there is $\frac{3}{9} = \cdot3333$, and the log. of $\cdot3333 = 1\cdot522835$

$$\begin{array}{r} 7 \\ \hline 2)4\cdot659845 \\ \hline 2\cdot329922 = \cdot02137 = \left(\frac{3}{9}\right)^{\frac{7}{2}}. \end{array}$$

Then $(\cdot131 + (1\cdot847 \times \cdot02137) \times \frac{11\cdot1^2 \times 55}{960} = 1\cdot2$ inch the head required. Table IV. gives the loss of head for bends in water pipes, both for the ordinary radius, and also for the loss by *quick* bends or elbows. It requires little explanation; by it it will be seen that an ordinary 8-inch bend, with a radius of 18 inches, consumes 3 inches head when discharging 1970 gallons per minute; while a quick 8-inch bend, with a radius of 6 inches, consumes 12 inches when passing nearly the

TABLE IV.—For bends in pipes, showing *loss of head* by change of direction by *one bend* of 90°.

Diam. Pipe. Inches.	Radius Centre Bend in Inches.	Head of Water Lost in Inches.													
		¼	½	¾	1	1½	2	3	4	5	6	9	12	18	24
		Gallons Discharged per Minute.													
2	12	36	51	63	73	81	103	126	146	163	179	219	252	309	358
3	12	83	117	144	166	203	235	288	332	371	407	498	576	705	814
4	12	145	205	252	291	356	411	504	582	650	713	873	1008	1233	1426
5	18	229	324	396	458	561	648	793	916	1024	1122	1374	1586	1944	2244
6	18	328	464	568	656	803	928	1136	1312	1467	1607	1968	2272	2784	3124
7	18	437	618	757	874	1070	1236	1514	1748	1954	2141	2622	3028	3708	4282
8	18	568	804	985	1137	1393	1608	1970	2274	2542	2786	3411	3940	4824	5572
9	18	709	1002	1228	1418	1737	2005	2456	2836	3170	3474	4254	4912	6015	6948
10	18	857	1212	1484	1714	2100	2424	2968	3428	3832	4199	5142	5936	7272	8398
12	21	1225	1733	2122	2451	3003	3466	4245	4902	5480	6005	7353	8490	10398	12010
15	24	1864	2635	3228	3728	4567	5271	6457	7456	8336	9134	11184	12914	15813	18268
18	27	2626	3714	4549	5253	6435	7428	9098	10506	11745	12870	15759	18196	22284	25740
21	30	3490	4935	6044	6980	8550	9870	12089	13960	15607	17100	20940	24178	29610	34200
24	33	4477	6330	7754	8954	10968	12661	15508	17908	20021	21937	26862	31016	37983	43870
Quick Bends.															
2	3	32	46	56	65	79	92	112	130	145	159	195	214	276	318
3	3½	63	89	109	126	154	178	218	252	282	309	378	436	534	618
4	4	98	139	170	197	241	278	341	394	440	480	591	682	834	966
5	4½	136	172	236	272	333	385	472	544	608	666	816	944	1155	1332
6	5	181	256	314	362	443	512	629	724	809	886	1086	1258	1536	1774
7	5½	229	322	396	458	561	645	793	917	1024	1122	1374	1586	1935	2244
8	6	281	398	487	563	689	796	975	1126	1259	1379	1680	1950	2388	2758

same quantity, or 1950 gallons. These heads, given in the table, are due simply to *change of direction*, and do not include the head due to velocity or friction in the pipe.

The total loss of head by friction in long pipes has therefore to be considered under three divisions—the loss of head by velocity of entry, the loss from friction in the pipe, and the loss by change of direction. The above table gives the loss for bends of 90° or quarter bends, but it is applicable to any other angle, for the loss of head is proportional to the angle; thus a bend of 45° will consume half the head of a bend of 90°, while a bend of 180° will consume double the amount, and so on.

In laying down water mains through a town, the diameters of the pipes in the several districts to which the supply is carried will vary according to the service required. In this case the head for each must be separately calculated and the sum-total taken, and the head for the bends then added. Again, the street lead-off service pipes from the main vary with the supply to the houses. A ½-inch pipe will give an intermittent supply to a house with six or seven rooms, a ⅝-inch pipe for ten rooms, ¾-inch pipe for sixteen rooms, and 1-inch pipe for twenty-five or thirty rooms as a general rule. The discharging power of long pipes varies as the 2·5 power of the diameter; thus, $4^{2\cdot5}=32$. Therefore, thirty-two pipes 1 inch diameter will be required to deliver, with the same head and length, the same quantity of water as a 4-inch pipe. The annexed table gives the branch service mains for water supply in towns.

TABLE V.

Diameter of Branch Mains.	Diameter of Lead Service Pipe.			
	½	⅝	¾	1
	Number of Houses Supplied.			
1½	15	9	6	3
2	32	18	12	6
2½	56	32	20	10
3	88	50	32	15
3½	...	74	47	23
4	...	104	66	32

The friction of pipes has been considered only in reference to pipes having a clean and smooth interior surface, such as that of a new cast-iron pipe, but the action of some soft waters which contain a large amount of oxygen rapidly decomposes the surface of the iron, forming rust, which is deposited over the interior surface in nodules and lumps. The increased friction from this cause is often very serious, and greatly reduces the amount of actual discharge. A water main at Torquay, some 14 miles in length, which should have discharged 616 gallons a minute, by the friction of deposited rust in the pipes fell off to 317 gallons per minute, or a loss of about 50 per cent. To prevent the action of rust, water pipes are usually coated over inside with a black varnish by a process invented by Dr. Angus Smith, and pipes so treated are found to last for years without being attacked by rust.

The laws regarding the issue of water in vertical columns or jets from a nozzle under a given head of pressure, such as fountain jets, &c., are at present very undetermined, and upon this subject more experimental information is necessary. Theoretically, when water issues vertically from a nozzle, as at M (fig. 6, Plate VI.), it should rise to the height O B of the head A B, but it is always found that the height of the jet is less than the head, a loss being caused by the resistance of the air. This difference is found to increase with the absolute height of the jet, and to diminish with an increase in the diameter. The best data on the subject are derived from the jets at Chatsworth and other well-known places, and are given in the annexed table, and from these results it will be observed that the difference between the height of the head and that of the jet is found to increase nearly in the ratio of the square of the head.

TABLE VI.—EXPERIMENTS ON THE HEIGHT OF FOUNTAIN JETS WITH DIFFERENT HEADS.

Diam. of Jet, in Inches.	Head on the Jet, in Feet.	Height of Jet, in Feet.		Error.	Loss of Height by Jet, in Feet.		Place.
		Experiment.	Calculated.		Experiment.	Calculated.	
2½	365	284	282	−2·0	81	83	Chatsworth.
1⅝	64	61	60·1	−0·9	3	3·9	Witley Court.
"	92	84	83·86	−0·14	8	8·14	"
"	115	103	102·3	−0·7	12	12·7	"
1	445	109	136·0	+27·0	336	309	Torquay.
¾	46	43	41·2	−1·8	3	4·8	Witley Court.
"	69	62	59·0	−3·0	7	10·0	"
"	92	77	74·4	−2·6	15	17·6	"
"	115	93	87·5	−5·5	22	27·5	"
"	141	98	99·6	+1·6	43	41·4	"
"	162	106	107·3	+1·3	56	54·7	"
⅝	15	14·25	14·44	+0·19	0·75	0·56	Weisbach.
"	30	27·81	27·75	−0·06	2·19	2·25	"
"	45	39·42	39·94	+0·52	5·58	5·06	"
"	60	48·36	51·00	+2·64	11·64	9·00	"
⅜	15	14·04	14·06	+0·02	0·96	0·94	"
"	30	26·44	26·25	−0·19	3·56	3·75	"
"	45	36·18	36·56	+0·38	8·82	8·44	"
"	60	42·96	45·00	+2·04	17·04	15·00	"
"	32	27	27·7	+0·7	5	4·3	Witley Court.
"	46	36	37·2	+1·2	10	8·8	"
"	95	55	57·4	+2·4	40	37·6	"
"	118	63	60·0	−3·0	55	58·0	"
$\frac{3}{16}$	28·8	19	21·9	+2·9	9·8	6·9	"
"	64	30	30·0	0.0	34·0	34·0	"

Taking ½-inch jet with 160 feet head, if there had been no resistance from the air it should have risen 160 feet, but by experiment it is found to rise only 80 feet; the difference is therefore 80 feet, and the difference h' is 80 feet. If with 80 feet head, the jet should rise 80 feet, but experimentally it is found to rise only 60 feet; the loss h' therefore is 20 feet. From these results it appears that with heads in the ratio of 1 to 2, the loss is in the ratio 1^2, 2^2, or 1 to 4, being 20 feet and 80 feet. Again, the head being constant, it is found that h' varies nearly in the inverse ratio to the diameter of the jet; because with 80 feet with a ½-inch jet 20 feet is lost, and with a 1-inch jet the loss would be about 10 feet, and the height of the jet 70 feet; while with ¼-inch jet the loss would reach about 40 feet and the height attained 40 feet. The formula for calculating the height of jets based upon the above data may be given as $h' = \frac{H^2}{d} \times \cdot 0125$; in which H is the head pressure on jet in feet; h' the difference between the height of head and the height of jet; d the diameter of jet in ⅛-inch. With this formula it will be found that each particular diameter of jet attains its maximum elevation with a certain head pressure, and that if the head is increased beyond that point, the height of the jet becomes less. The cause of this may be that the issuing stream by excessive pressure is broken into spray, and thus meets with greater resistance from the air than a jet of solid water thrown up by a more moderate pressure. When excessive pressure is employed the loss h' is enormous. With a jet 1-inch diameter and 445 feet head, the elevation attained was only 109 feet. The amount of water discharged varies considerably with the *form* of the nozzle, and the solidity of the issuing stream is also affected as well as the height of the jet. As jets are generally placed at the end of a long pipe or series of pipes, as in the instance of the fountains at the Crystal Palace and other places, allowance must be made for the loss of head by the friction in such pipes so as to obtain the actual head *on the jet*, for which only the formula and table has value.

When the discharge of the jet takes place in an oblique direction, and out of the perpendicular, the path described by the water is that of a parabola. For calculating the velocities of discharge and heights of jet, &c., the annexed tables of velocities in falling bodies will be found useful references:—

TABLE VII.—SPACE FALLEN THROUGH BY BODIES TO ACQUIRE CERTAIN VELOCITIES.

Velocity in feet per Second.	Space.	Velocity in feet per Second.	Space.	Velocity in feet per Second.	Space.
	Ft. In.		Ft. In.		Ft. In.
1	0 $0\frac{3}{16}$	21	6 10	41	26 1
2	0 $0\frac{3}{4}$	22	7 6	42	27 5
3	0 $1\frac{5}{8}$	23	8 3	43	28 9
4	0 3	24	9 0	44	30 1
5	0 $4\frac{5}{8}$	25	9 9	45	31 5
6	0 $6\frac{3}{4}$	26	10 6	46	32 10
7	0 $9\frac{1}{8}$	27	11 4	47	34 4
8	1 0	28	12 3	48	36 10
9	1 $3\frac{1}{4}$	29	13 0	49	37 4
10	1 $6\frac{3}{4}$	30	14 0	50	38 11
11	1 $10\frac{1}{2}$	31	14 11	52	42 0
12	2 3	32	15 11	54	45 4
13	2 $7\frac{1}{2}$	33	16 11	56	50 0
14	3 $0\frac{3}{4}$	34	18 0	58	52 0
15	3 6	35	19 0	60	56 0
16	4 0	36	20 1	62	59 8
17	4 6	37	21 5	64	63 8
18	5 0	38	22 6	66	67 8
19	5 7	39	23 9	68	72 0
20	6 3	40	24 11	70	76 0

TABLE VIII.—FALLING BODIES.

Time, Seconds.	Whole Space Fallen.	Velocity acquired, Feet per Second.	Time, Seconds.	Whole Space Fallen.	Velocity acquired, Feet per Second.
	Ft. In.			Ft. In.	
$\frac{1}{10}$	0 $1\frac{15}{16}$	3·2	$1\frac{1}{10}$	19 $4\frac{3}{8}$	35·2
$\frac{2}{10}$	0 $7\frac{5}{8}$	6·4	$1\frac{2}{10}$	23 $0\frac{1}{2}$	38·4
$\frac{3}{10}$	1 $5\frac{1}{4}$	9·6	$1\frac{3}{10}$	27 $0\frac{1}{2}$	41·6
$\frac{4}{10}$	2 $6\frac{3}{4}$	12·8	$1\frac{4}{10}$	31 $4\frac{3}{8}$	44·8
$\frac{5}{10}$	4 0	16·0	$1\frac{5}{10}$	36 0	48·0
$\frac{6}{10}$	5 $9\frac{1}{8}$	19·2	$1\frac{6}{10}$	41 0	51·2
$\frac{7}{10}$	7 10	22·4	$1\frac{7}{10}$	46 $2\frac{5}{8}$	54·4
$\frac{8}{10}$	10 $2\frac{7}{8}$	25·6	$1\frac{8}{10}$	51 1	57·6
$\frac{9}{10}$	12 $11\frac{1}{2}$	28·8	$1\frac{9}{10}$	57 $9\frac{1}{8}$	60·8
1	16 0	32·0	2	64 0	64·0

Oblique jets of great height and range, such as those from the hose of a fire engine, deviate considerably from the true parabolic curve, but for moderate heights and ranges, such as usually occur, the deviation is not considerable. The construction of ornamental jets, where the issuing stream is made to assume various forms, may be used with great effect in the interior of conservatories, &c., where the air is quiet, or in very sheltered situations. These ornamental jets are called by various names: the "convolvulus," in which, by the pressure of a very small head, the water escapes horizontally in a very thin and flat circular sheet, which, falling over, produces the convolvulus shape, and to produce a sheet 3 feet in diameter will require 6 gallons per minute; the "dome," or globe jet, in which by a 2 feet head the water forms a hollow globe, falling downwards, of about 14 inches diameter, with an expenditure of some 3 gallons per minute. The "basket and ball" is another curious variety, in which a ball is caught up by the jet and kept balanced upon the top of the column of water, the basket being placed to catch the ball should it lose its equilibrium and return it back to the jet to be once more thrown up.

An ingenious form of self-acting fountain, said to have been invented by Hero of Alexandria, is shown (fig. 7, Plate VI.): W V is a basin containing water, and from the bottom of this vessel a tube, A B, descends into a lower chamber, P O, containing air and water. Underneath the basin is attached a second air-tight vessel, L M N K, into which the tube, G F, descends through the basin nearly to the bottom. A connecting tube, T S, passes from the top of the lowest vessel through the chamber M N, reaching nearly to the bottom surface of the upper basin; the adjutage is fixed at G. The action of the fountain is simple. The chamber L M N K is filled with water up to the level of the tube T; a certain amount of air will therefore remain confined in the vessel unable to escape. When water is poured into the basin W V, it descends through the tube A B into the lower chamber P O, until the compressed air in that chamber, acting upon the surface of the water *c c* O, balances the column of water A B. This compressed air, passing up the tube S T, will also act upon the surface, *e* E, of the water in the upper chamber, which cannot escape up the tube F G so long as the stopcock A is closed. On this being opened the jet G H is forced up, and as the water falls into the basin it descends through A B into the lower chamber, the water in which, increasing in volume, is constantly compressing the air, and by this means the pressure is kept up, and the fountain continues to play so long as any air is left in the lower chamber. When this is full it is emptied by the tap and tube R.

ARITHMETIC.—CHAPTER V.

MULTIPLES, MEASURES, AND FACTORS DEFINED.

THE GREATEST COMMON MULTIPLE—THE GREATEST COMMON MEASURE—EXERCISES.

MULTIPLICATION means the increasing of things. It is seen by experience to be a property of many of the things that exist around us to increase in numbers, and it becomes our interest to know how to calculate the results of all the possible multiplications we may feel interested in. Multiplication is the process by which this is worked out by figures in arithmetic. In many frequently recurring cases we have acquired by habit and exercise the capacity of almost instantaneously perceiving the parts, or collocations of parts, which will make up the wholes of the numbers we require, that is, the multiples of certain given numbers.

Divisibility, in its ordinary signification, is that property of things by which they are separable into parts, or are regarded by the mind as so separable. In division of whole numbers the term divisible means separable into definite parts without introducing fractions into the result. Division, as an arithmetical process, denotes the operation by which we ascertain how many times and parts of times one number is contained in another. In actual practice, division consists of a continual approximation towards the result. If the given numbers are 842 to be divided by 2, and 1284÷4, they immediately resolve themselves into

$$\left.\begin{array}{r} 800\div2=400 \\ 40\div2=\ \ 20 \\ 2\div2=\ \ \ \ 1 \end{array}\right\}421.\ \text{Ans.} \qquad \left.\begin{array}{r} 1200\div4=300 \\ 80\div4=\ \ 20 \\ 4\div4=\ \ \ \ 1 \end{array}\right\}321.\ \text{Ans.}$$

Similarly,

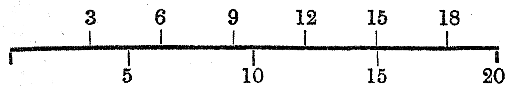
$$67635\div5=\left.\begin{array}{c} {}^{5})\underline{60000}\ {}^{5})\underline{7000}\ {}^{5})\underline{600}\ {}^{5})\underline{30}\ {}^{5})\underline{5} \\ 12000+1400+120+\ 6+1 \end{array}\right\}=13527.$$

A great many facts regarding multiplication and division have been collected by mathematicians, and have been reduced to formulæ and rules, upon which we can rely for working out questions of various sorts in which these processes are involved. These are technically called *multiples* and *measures*, and a knowledge of the facts about them enables us often greatly to abbreviate the labour of multiplication and division. The processes are in themselves of no very great importance or difficulty, but they come to be of great service when we require to pursue our studies in arithmetic beyond whole numbers, and proceed to investigate and apply the arithmetic of fractions. A few explanations and examples of these facts concerning the readiest possible methods of simplifying arithmetical processes will not only inform us upon these points, but confirm and exercise our knowledge of multiplication and division.

When one number divides another without leaving any remainder, or is contained in it an exact number of times, it is said to *measure* it or to be a *measure* of that number. Again, a number that can be measured by any other is called

a *multiple* of that other number. Suppose that we have a log of wood, of considerable length, to measure, and that we are provided with two rods, one 3 and the other 5 feet long, but without any divisions marked upon them. We will only be able to effect the required measurement, should it happen that the length of the log is some determinate number of times the length of one of the rods. If we try the 3-feet rod, and after measuring off six times its length, find that there is a portion of the length to be measured remaining, which

——— = the 3-feet rod. ——————— = the 5-feet rod.



is less than another length of the rod, the measure employed fails, for it does not inform us how much shorter the unmeasured portion is than 3 feet; all that we learn is, that the log is more than 18 and less than 21 feet long. But if on applying the 5-feet rod we find that it measures the length, we are satisfied that the length of the log is just 20 feet. This is found by multiplying the *measure* 5 feet by 4, and this is what we mean by saying that 20 feet is a *multiple* of 5 feet. The same mode of reasoning may be be employed of whatever sort of units 5 and 20 are composed; 20 gallons, for instance, can be measured by means of a 5-gallon vessel, but not by a vessel of 3-gallon capacity. We may therefore conclude, without regard to the kind of things numbered, that 5 measures 20, and that 20 is a multiple of 5. Therefore *measure* is a particular name for a divisor which leaves no remainder; and *multiple* for a number which is made up by multiplying two or more other numbers together. 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, &c., are *multiples* of each other, and 3 is a *measure* of each number that follows it.

We have already shown that 5 is a measure of 20, but it is not the only measure; for 2, 4, and 10 are also divisors of 20 which leave no remainder, and even 1 and 20 come within the meaning of the term, the first giving a quotient 20, and the latter a quotient 1. Therefore 1, 2, 4, 5, 10, 20 are all *measures* of 20, and consequently 20 is a *multiple* of these numbers. It follows from this that a number which is divisible by any two or more numbers is divisible by the product of all the numbers by which it is thus divisible. We present in the form of a table, which the student may profitably study and easily amplify, instances of the mode of simplifying divisions:—

5214	being divisible by	2	and	3	is also divisible by	6 = 869.
348	"	3	"	4	"	12 = 29.
615	"	3	"	5	"	15 = 41.
846	"	2	"	9	"	18 = 47.
714	"	3	"	7	"	21 = 34.
1248	"	3	"	8	"	24 = 52.
4536	"	4	"	9	"	36 = 126.
2816	"	4	"	11	"	44 = 64.
3825	"	5	"	9	"	45 = 85.
4248	"	8	"	9	"	72 = 59.
6480	"	5	"	8 and 9	"	360 = 18.

What has been already said may be generalized and made perhaps more readily understood in these words. Every number which can be divided by any other number without leaving a remainder is called a *multiple* of it. The *factors* of a number are those numbers by the multiplication of which that number is made up; and the number made up by the multiplication of all the factors of any other number or numbers is called *the greatest common measure* or divisor (for measure is only the old word for divisor). If any two numbers have a common measure, *that* also measures (1) their sum, and (2) their difference; as, 42 and 63 have each the common measure 7; 7 therefore will measure 105, their sum, and 21, their difference. Of 63, 3, 3, and 7 are factors; 7, 9, and 21 are multiples; and of it and 42, 21 is the greatest common measure. In regard to this matter we may observe (1) that the product of any two numbers is a multiple of both, as $8 \times 9 = 72$; 72 is therefore divisible both by 8 and by 9; (2) that if these two numbers have a common measure greater than 1, there must be a common multiple less than this product, as $6 \times 9 = 54$; but both 6 and 9 are divisible by 3; hence $6 \div 3 = 2$, $9 \div 3 = 3$, and therefore 18 and 27 are less common multiples than 54; and (3) that if any two numbers have no common measure except 1, the least common multiple is their product; *e.g.* 8 and 7 have no common measure, and therefore $8 \times 7 = 56$ is their least common multiple. When a number, however, has no other measures than 1 and itself, it is called a *prime number*. Of this character are the 168 numbers in the following table, which (with the exception of 1) contains all the prime numbers below 1000:—

2	3	5	7	11	13	17	19	23	29	31	37
41	43	47	53	59	61	67	71	73	79	83	89
97	101	103	107	109	113	127	131	137	139	149	151
157	163	167	173	179	181	191	193	197	199	211	223
227	229	233	239	241	251	257	263	269	271	277	281
283	293	307	311	313	317	331	337	347	349	353	359
367	373	379	383	389	397	401	409	419	421	431	433
439	443	449	457	461	463	467	479	487	491	499	503
509	521	523	541	547	557	563	569	571	577	587	593
599	601	607	613	617	619	631	641	643	647	653	659
661	673	677	683	691	701	709	719	727	733	739	743
751	757	761	769	773	787	797	809	811	821	823	827
829	839	853	857	859	863	877	881	883	887	907	911
919	929	937	941	947	953	967	971	977	983	991	997

None of these can be divided exactly by any other number except itself and 1. No prime number—except 2 and 5—ends with 2, 4, 5, 6, or 8; and therefore every number ending in these figures is capable of yielding a *measure*.

It is often of importance to ascertain whether a given number is prime or not. The only way to satisfy ourselves on this head is to try if we can find some number that will measure it. If we are sure that it has no other measure than itself and 1, we are of course sure that it is a prime. This process may appear laborious, and so it is, when the number is large, but still it may be done. The work is simplified by the following considerations:—

1. The greatest factor which a number can have is its *half;* should it therefore have a factor so great, it must be divisible by 2.

2. If a number be divisible by any other, it is divisible by all the factors of that other.

3. If a number be not divisible by any prime number, which is not greater than its square root,* it is not divisible by any number whatever, and is therefore itself a prime number. Thus 119 is a prime, for it is not measured by 2, 3, 5, or 7, and the next prime number 11 is greater than its square root, *i.e.* $11 \times 11 = 121$.

We may take now one example of the decomposition of a number into its *prime factors.* Let the number be 1260. The question is to find out of what factors it is the product; that is, what factors must be measures of it. For convenience of working let us begin by trying as divisors the lowest prime numbers given in the foregoing table, employing each as often as it will succeed. In the example we find that 2 succeeds twice, 3 twice, and 5 and 7 each once. The simple measures then of 1260 are 2, 2, 3, 3, 5, and 7, and these are what we term its prime factors. We may therefore write—

2	1260
2	630
3	315
3	105
5	35
7	7
	1

$$1260 = 2 \times 2 \times 3 \times 3 \times 5 \times 7$$

In the same way it may be proved that

$255 = 3 \times 5 \times 17$ $1035 = 3 \times 3 \times 5 \times 23$
$518 = 2 \times 7 \times 37$ $714 = 2 \times 3 \times 7 \times 17$

Two numbers are said to be *prime to each other* when they have no factor in common, and are not *both* measured by any other number than 1. Thus 21 and 40 are both composite numbers; as,

$$21 = 3 \times 7, \text{ and } 40 = 2 \times 2 \times 2 \times 5;$$

* By *square root* is meant a number which, being multiplied into itself, gives a product equal to the number. Thus 5 is called the square root of 25, because 5 times $5 = 25$. The method of finding the square root of a number accurately will be afterwards explained, but the mere definition is enough for our present purpose.

but they are prime to each other, for no factor of the one number is a factor of the other. When a factor of one number is found in the other, that factor is called a *common measure.* Take the numbers 300 and 275, then

$$300=2\times2\times3\times5\times5, \text{ and } 275=5\times5\times11.$$

Here it appears that the factors 5×5 are common to the two numbers; they have therefore a common measure $=25$. This is also their greatest common measure; for none of the other factors being common, were each number divided by this measure the quotients would be prime to each other, and admit of no common measure greater than 1; as,

$$300\div5\times5=2\times2\times3, \text{ and } 275\div5\times5=11.$$

This method of determining the greatest common measure, although exceedingly simple in principle, is laborious in practice when the numbers are large, and is therefore usually abandoned for a more direct method. That method rests upon the following principles:—

1. If a number measures two others, it measures their sum and difference. As an instance, 8 measures 32 and 136; it therefore measures $136+32=168$, and $136-32=104$.

2. If a number measures another, it measures any multiple of that other. For example, 5 measures 15; it therefore measures $15\times2=30$; $15\times3=45$; $15\times4=60$, &c.

From the foregoing principles we readily deduce the following:—

(1). Every common measure of a dividend and divisor is also a common measure of the divisor and remainder; *e.g.* let 216 be divided by 96. The quotient is 2, and the remainder 24; that is, $216=96\times2+24$. From this it follows, that 96×2 is just 24 less than 216, or that $216-96\times2=24$. Take now any number, as 8, which measures 216 and 96; then because it measures 216 and 96, it measures 216 and 96×2, and also their difference, which is 24; therefore every common measure of 216 and 96 is also a measure of 96 and 24. The same reasoning may be applied to all the common measures of 216 and 96 and the remainder 24, and therefore to their greatest.

(2). Every common measure of the remainder and divisor is also a common measure of the dividend and divisor. Observe in the foregoing example that $216=96\times2+24$, and take any common measure, as 12, of the remainder 24 and divisor 96. Then because 12 measures 24 and 96, it measures 24 and 96×2 and their sum $96\times2+24$, which is the dividend 216. This reasoning applies to all the common measures of the remainder and divisor; hence these numbers have no common measure which is not also a common measure of the divisor and dividend.

By (1), then, it is proved that the remainder and divisor have all the common measures which the dividend and divisor have; and by (2) it is proved that they have no others. Consequently the greatest common measure of the dividend and divisor is also the greatest of the divisor and remainder. To show how these principles are applied, let us take a question, and for convenience let g. c. m. stand for the words *greatest common measure.*

What is the g. c. m. of the numbers 1133 and 231?

$$\left.\begin{array}{l}\text{Dividing } 1133 \text{ by } 231\\ \text{Dividing } 231 \text{ by } 209\\ \text{Dividing } 209 \text{ by } 22\\ \text{Dividing } 22 \text{ by } 11\end{array}\right\}\text{ we get for remainder }\left\{\begin{array}{r}209\\22\\11\\0\end{array}\right.$$

Since then 11 divides 22 without remainder, and since it is the greatest number which divides itself without remainder,

$$\begin{array}{lll}\text{Therefore} & 11 \text{ is g. c. m. of } 22 \text{ and } 11 & \\ \text{But g. c. m. of } 22 \text{ and} & 11 \text{ is g. c. m. of } 209 \text{ and } 22 & \multirow{3}{*}{\text{by(1).}}\\ \text{,, g. c. m. of } 209 \text{ and} & 22 \text{ is g. c. m. of } 231 \text{ and } 209 & \\ \text{,, g. c. m. of } 231 \text{ and } 209 & \text{is g. c. m. of } 1133 \text{ and } 231 & \\ \text{Therefore} & 11 \text{ is g. c. m. of } 1133 \text{ and } 231 & \text{by(2).}\end{array}$$

This process is shown below, and the following is called the rule for finding the greatest common measure of two numbers:—

I. *Divide the greater of the two numbers by the less, until a remainder is obtained which is less than the divisor.*

II. *Make the remainder thus obtained a divisor, and the former divisor a dividend, and proceed as in* I. *to find another remainder.*

III. *Continue in this way, always dividing the preceding remainder by the last obtained, until one is obtained which exactly divides or measures the preceding remainder. This last divisor is the common measure sought.*

```
231)1133(4
     924
     ---
     209)231(1
         209
         ---
          22)209(9
             198
             ---
              11)22(2
                 22
                 --
                  0
```

∴ g. c. m. is 11.

IV. *Should the process not terminate until the last divisor is* 1, *the numbers are prime to each, or they admit of no other common measure than* 1.

This rule has been run into the following quaint rhyme by an old arithmetician:—

"The *greater* by the *less* divide;
The *less* by *what remains* beside;
The *last divisor,* then again
By *what remains,* till nought remain;
And *what divides and leaveth nought*
Will be the *common measure sought.*"

The following numbers may be proposed for exercise in this rule:—

Numbers proposed.		g. c. m.	Numbers proposed.		g. c. m.
1261	1313	13	3760	9024	752
833	15785	7	791	8989	1
143	1271	1	5537	62923	7

When we require to find the greatest common measure of more than two numbers, the same rule is applicable, thus:—Find the greatest common measure of the first and second numbers, and of this common measure and the third number. This is evident; for the greatest common measure of the first and second contain *all* the common divisors of these numbers and no others; whatever factor then is common to all the three numbers, is also common to the third number and to the greatest common measure of the first and second, and no others. The same reasoning may be extended to other numbers.

It is as desirable to have a method of determining the *least common multiple* of numbers as it is to be able to find their greatest common measure. It is obvious that the product of any two numbers is a multiple of these two—*e.g.* 9×12 or 108, is a common multiple of 9 and 12. But it is not *the least;* for 36 and 72 are also multiples, and they are less than 108. To know how a less common multiple is found, observe that $9=3\times3$, and that $12=3\times4$; the greatest common measure of the numbers is therefore 3. Then $9\div3=3$, and $12\div3=4$; and these quotients 3 and 4 being multiplied together, and the product being multiplied by the greatest common measure gives $(3\times4)\times3=36$, which is a common multiple of 9 and 12. It is also the least common multiple; but the demonstration, to be understood, requires some knowledge of algebra. The advantage of using the least common multiple rather than any other, is that in some operations we thereby work with smaller numbers than we otherwise would do. The results are, however, the same—just as the change of a sovereign is the same whether told down in 20 shillings or 240 pence. Although, however, we cannot absolutely prove this, by patient trial really we may satisfy ourselves in every case that the following are convenient practical rules for finding common multiples.

1. When the numbers proposed have no other common measure than 1, their product is their common multiple. Thus, 53×103 are prime numbers, therefore their common multiple is $53\times103=5459$.

2. When the numbers proposed have a common measure, divide their product by it, and the quotient will be the common multiple sought. The easiest way of putting this rule into practice is to divide *one* of the numbers by the common measure, and to multiply the other number by the quotient.

Thus, 360 and 210 have a common measure 30, therefore their common multiple is $(360 \times 210) \div 30 = 2520$.

To extend this rule to more than two numbers, find a common multiple of the first two, then of that common multiple and the third number, and so on.

3. It frequently happens that a common multiple of several small numbers is required. When this is the case, the best method of proceeding is as follows:—Let the numbers be

7 2 8 5 15 3 12 18 21

Strike out all those numbers which are evidently divisors of some of the others, as 7, which divides 21; 2 and 3, which are found in 12; and 5, which is a factor of 15. The remaining numbers are then

8 15 12 18 21

Resolve all these into their prime factors as follows:—

$2 \times 2 \times 2 \quad 5 \times 3 \quad 3 \times 2 \times 2 \quad 3 \times 3 \times 2 \quad 3 \times 7$

Take now each prime factor as often as it occurs in that one of the preceding which has it most often, but no oftener; this gives

2 2 2 3 3 5 7

Multiply all these together, which gives

$$2 \times 2 \times 2 \times 3 \times 3 \times 5 \times 7 = 2520,$$

the common multiple required for the given numbers.

This is fully more conveniently done by dividing successively by the prime factors. Thus, neglecting 7, 2, 3, and 5, as before, because every multiple which is common to the other numbers of which they are simply factors, must be common to them also; and arranging the operation as it is at the side, we divide successively such numbers as will divide by the prime factors; and by each as long as possible; and bringing down the other numbers, we proceed in this way till the whole of the dividends disappear. When this is accomplished, the product of the prime factors employed as divisors is the common multiple sought. These, it will be observed, are the same by the last process as by the first; or rather they are the same by both ways of writing the same process.

2	8	15	12	18	21
2	4	15	6	9	21
2	2	15	3	9	21
3	1	15	3	9	21
3		5	1	3	7
5		5		1	7
7		1			7
					1

Practice will suggest several abbreviations in all the processes of this chapter, and especially in such operations as the last. This will come into actual use in our study of fractions.

We subjoin a few cases for exercise (1) on the rules for finding a common multiple:—

Numbers proposed.	Common multiple.
12 16 30	240
16 18 22	1584
56 512	3584
98 716	35084
3 7 5 14 15 20	420
14 7 9 21 18 36 42	252
8 13 17 11 6 15	291720
144 210 360	5040
864 876	63072

(2) On those for finding the greatest common measure:—

Numbers proposed.		g. c. m.	Numbers proposed.	g. c. m.
9	21	3	56 63 84	7
72	126	18	27 45 54	9
16	24	4	32 40 64 108	8
42	18	6	5187 5850	39
360	112	8	1792 1832	8
637	143	13	204 1190 1445 2006	17
432	816	48	6441 10283	113
342	665	19		

THE LATIN LANGUAGE.—CHAPTER VI.

PARADIGMS OF LATIN VERBS—THE FOUR CONJUGATIONS—EXERCISES IN CONJUGATION.

The model paradigms of verbs which grammarians present to us exhibit at one view all the possible parts of this class of words that we can either see in reading or require to use in speaking or writing. They place before us the ideal structure or essential type of the verb. Its ground-plan is governed, of course, by the method in which the Romans thought, and the main difficulty perhaps which the study of the Latin verb presents to us arises from the difference in the mode of thought employed in a nation which has analyzed and disparted the various elements of thought, and that necessarily used by those whose verbs were synthetic—*i.e.* held together in a unity several elements of thought. For example, the Romans said in one long word—*vocavissēmus*—what we say in four short ones—"we might have called." We require to get our minds to take in and to keep constantly present before them the fact of this synthetic expression of thought—of this want of breaking it up, as it were, and dissecting it into its elementary parts, as well as to acquire the habit of realizing, in our use of the language, those much-meaning forms into which Roman thought moulded itself. That we may the more readily do so, grammarians have gathered together and arranged in a regular and systematic manner a complete series of all the forms, simple and composite, in which the Romans registered and expressed the statements they required to make. These, being all joined together and placed before us at once, appear to be not only numerous but cumbrous, especially when exhibited in different paradigms, which show the special changes that occur in the orthography and form of the tense-endings of verbs having particular characteristics, enabling them to be classified in such a way as to be distinguished from each other. The student who would like to attain to a clear apprehension of the specific forms of the Latin verb should endeavour to comprehend the theory of its construction, as a tracing out in an ideal of all the possible forms which thought assumed in the mind of a Roman, and a distinct representation of the means he employed (or could employ) for the expression of the different shades of change to which each thought was (or might be) subject.

The meaning involved in the tense-endings and modal peculiarities of verbs are the same throughout the whole series of conjugations, and though there is, in the form in which they respectively appear in the separate paradigms, some diversities which require attention and care, yet on the whole these are in reality the result rather of the orthographical machinery of the language than of any distinct necessity originating in the nature of the thoughts to be expressed. The possession of this capacity of indicating several elements of thought combined into a single word is one of the characteristics which distinguish the verb from the adjective. The latter denotes a quality or power possessed, but the former implies a quality or power not only possessed, but exercised at a certain time, in given conditions. For example, the crude form *am* suggests the idea of love. If it is desired to show that this quality is actively exercised by a third person, now, we say *amat*, he or she loves, for the verb does not in general include any sign of gender; if we wish to indicate that this quality is possessed, and is capable of acting or free to act, within a third person regarding another, we say *amet*, he or she may love; and if we are resolved to call this act into exercise we say *ama*, love [thou]. Thus the verb is so complicated in structure that, besides conveying the idea of the quality possessed and exercised, it informs us *who* performs it, *when* it is done, *how* or under what conditions it operates. These changeable elements of thought are indicated in the verb by adding to the crude form of it (*i.e.* the part which names the sort of activity which may be exercised and of which we can make affirmation) certain terminations, which are by convention used to suggest, through changes made in them, the changes which do or may (or can be supposed to) take place in the actual exercise of the quality or attribute which the verb indicates. It is of great importance to acquire a thorough knowledge of these terminations and their significations, and an instantaneous power of reproducing them.

Indicative Mood.

	FIRST CONJUGATION.		SECOND CONJUGATION.	
	ACTIVE.	PASSIVE.	ACTIVE.	PASSIVE.
Present Tense.	S. Am-o, *I love* am-as, *thou lovest* am-at, *he loves* Pl. am-āmus, *we love* am-ātis, *ye love* am-ant, *they love*	S. Am-or, *I am* am-āris, *thou art* am-ātur, *he is* Pl. am-āmur, *we are* am-amĭni, *ye are* am-antur, *they are* *loved*	S. Mon-eo, *I advise* mon-es, *thou advisest* mon-et, *he advises* Pl. mon-ēmus, *we advise* mon-ētis, *ye advise* mon-ent, *they advise*	S. Mon-eor, *I am* mon-ēris, *thou art* mon-ētur, *he is* Pl. mon-ēmur, *we are* mon-emĭni, *ye are* mon-entur, *they are* *advised*
Imperfect.	S. am-ābam, *I was* am-ābas, *thou wast* am-ābat, *he was* Pl. am-abāmus, *we were* am-abātis, *ye were* am-ābant, *they were* *loving*	S. am-ābar, *I was* am-abāris, *thou wast* am-abātur, *he was* Pl. am-abāmur, *we were* am-abamĭni, *ye were* am-abantur, *they were* *(being) loved*	S. mon-ēbam, *I was* mon-ēbas, *thou wast* mon-ēbat, *he was* Pl. mon-ebāmus, *we were* mon-ebātis, *ye were* mon-ēbant, *they were* *advising*	S. mon-ēbar, *I was* mon-ebāris, *thou wast* mon-ebātur, *he was* Pl. mon-ebāmur, *we were* mon-ebamĭni, *ye were* mon-ebantur, *they were* *(being) advised*
Perfect.	S. am-āvi, *I loved* am-avisti, *thou lovedst* am-āvit, *he loved* Pl. am-avĭmus, *we loved* am-avistis, *ye loved* am-avērunt, *they loved*	S. am-ātus sum, *I was* am-ātus es, *thou wast* am-ātus est, *he was* Pl. am-āti sumus, *we were* am-āti estis, *ye were* am-āti sunt, *they were* *loved*	S. mon-ui, *I advised* mon-uisti, *thou advisedst* mon-uit, *he advised* Pl. mon-uĭmus, *we advised* mon-uistis, *ye advised* mon-uērunt, *they advised*	S. mon-ĭtus sum, *I was* mon-ĭtus es, *thou wast* mon-ĭtus est, *he was* Pl. mon-ĭti sumus, *we were* mon-ĭti estis, *ye were* mon-ĭti sunt, *they were* *advised*
Pluperfect.	S. am-avĕram, *I had* am-avĕras, *thou hadst* am-avĕrat, *he had* Pl. am-averāmus, *we had* am-averātis, *ye had* am-avĕrant, *they had* *loved*	S. am-ātus eram, *I had* am-ātus eras, *thou hadst* am-ātus erat, *he had* Pl. am-āti erāmus, *we had* am-āti erātis, *ye had* am-āti erant, *they had* *been loved*	S. mon-uĕram, *I had* mon-uĕras, *thou hadst* mon-uĕrat, *he had* Pl. mon-uerāmus, *we had* mon-uerātis, *ye had* mon-uĕrant, *they had* *advised*	S. mon-ĭtus eram, *I had* mon-ĭtus eras, *thou hadst* mon-ĭtus erat, *he had* Pl. mon-ĭti erāmus, *we had* mon-ĭti erātis, *ye had* mon-ĭti erant, *they had* *been advised*
Future Simple.	S. am-ābo, *I shall* am-ābis, *thou wilt* am-ābit, *he will* Pl. am-abĭmus, *we shall* am-abĭtis, *ye will* am-ābunt, *they will* *love*	S. am-ābor, *I shall* am-abĕris, *thou wilt* am-abĭtur, *he will* Pl. am-abĭmur, *we shall* am-abimĭni, *ye will* am-abuntur, *they will* *be loved*	S. mon-ēbo, *I shall* mon-ēbis, *thou wilt* mon-ēbit, *he will* Pl. mon-ebĭmus, *we shall* mon-ebĭtis, *ye will* mon-ēbunt, *they will* *advise*	S. mon-ēbor, *I shall* mon-ebĕris, *thou wilt* mon-ebĭtur, *he will* Pl. mon-ebĭmur, *we shall* mon-ebimĭni, *ye will* mon-ebuntur, *they will* *be advised*
Future Perfect.	S. am-avĕro, *I shall* am-avĕris, *thou wilt* am-avĕrit, *he will* Pl. am-averimus, *we shall* am-averitis, *ye will* am-avĕrint, *they will* *have loved*	S. am-ātus ero, *I shall* am-ātus eris, *thou wilt* am-ātus erit, *he will* Pl. am-āti erĭmus, *we shall* am-āti erĭtis, *ye will* am-āti erunt, *they will* *have been loved*	S. mon-uĕro, *I shall* mon-uĕris, *thou wilt* mon-uĕrit, *he will* Pl. mon-uerimus, *we shall* mon-ueritis, *ye will* mon-uĕrint, *they will* *have advised*	S. mon-ĭtus ero, *I shall* mon-ĭtus eris, *thou wilt* mon-ĭtus erit, *he will* Pl. mon-ĭti erĭmus, *we shall* mon-ĭti erĭtis, *ye will* mon-ĭti erunt, *they will* *have been advised*

Subjunctive Mood.

	FIRST CONJUGATION.		SECOND CONJUGATION.	
	ACTIVE.	PASSIVE.	ACTIVE.	PASSIVE.
Present Tense.	S. am-em, *I may* am-es, *thou mayst* am-et, *he may* Pl. am-ēmus, *we may* am-ētis, *ye may* am-ent, *they may* *love*	S. am-er, *I may* am-ēris, *thou mayst* am-ētur, *he may* Pl. am-ēmur, *we may* am-ēmini, *ye may* am-entur, *they may* *be loved*	S. mon-eam, *I may* mon-eas, *thou mayst* mon-eat, *he may* Pl. mon-eāmus, *we may* mon-eātis, *ye may* mon-eant, *they may* *advise*	S. mon-ear, *I may* mon-eāris, *thou mayst* mon-eātur, *he may* Pl. mon-eāmur, *we may* mon-eamĭni, *ye may* mon-eantur, *they may* *be advised*
Imperfect.	S. am-ārem, *I might* am-āres, *thou mightst* am-āret, *he might* Pl. am-arēmus, *we might* am-arētis, *ye might* am-ārent, *they might* *love*	S. am-ārer, *I might* am-arēris, *thou mightst* am-arētur, *he might* Pl. am-arēmur, *we might* am-aremĭni, *ye might* am-arentur, *they might* *be loved*	S. mon-ērem, *I might* mon-ēres, *thou mightst* mon-ēret, *he might* Pl. mon-erēmus, *we might* mon-erētis, *ye might* mon-ērent, *they might* *advise*	S. mon-ērer, *I might* mon-erēris, *thou mightst* mon-erētur, *he might* Pl. mon-erēmur, *we might* mon-eremĭni, *ye might* mon-erentur, *they might* *be advised*
Perfect.	S. am-avĕrim, *I may* am-avĕris, *thou mayst* am-avĕrit, *he may* Pl. am-averimus, *we may* am-averitis, *ye may* am-avĕrint, *they may* *have loved*	S. am-ātus sim, *I may* am-ātus sīs, *thou mayst* am-ātus sit, *he may* Pl. am-āti sīmus, *we may* am-āti sītis, *ye may* am-āti sint, *they may* *have been loved*	S. mon-uĕrim, *I may* mon-uĕris, *thou mayst* mon-uĕrit, *he may* Pl. mon-uerimus, *we may* mon-ueritis, *ye may* mon-uĕrint, *they may* *have advised*	S. mon-ĭtus sim, *I may* mon-ĭtus sīs, *thou mayst* mon-ĭtus sit, *he may* Pl. mon-ĭti sīmus, *we may* mon-ĭti sītis, *ye may* mon-ĭti sint, *they may* *have been advised*
Pluperfect.	S. am-avissem, *I should* am-avisses, *thou wouldst* am-avisset, *he would* Pl. am-avissēmus, *we should* am-avissētis, *ye would* am-avissent, *they would* *have loved*	S. am-ātus essem, *I should* am-ātus esses, *thou w'ldst* am-ātus esset, *he would* Pl. am-āti essēmus, *we should* am-āti essētis, *ye would* am-āti essent, *they would* *have been loved*	S. mon-uissem, *I should* mon-uisses, *thou wouldst* mon-uisset, *he would* Pl. mon-uissēmus, *we should* mon-uissētis, *ye would* mon-uissent, *they would* *have advised*	S. mon-ĭtus essem, *I should* mon-ĭtus esses, *thou w'ldst* mon-ĭtus esset, *he would* Pl. mon-ĭti essēmus, *we should* mon-ĭti essētis, *ye would* mon-ĭti essent, *they would* *have been advised*

Note.—The imperatives, infinitives, gerunds, supines, and participles of these conjugations will be found on page 418.

THIRD CONJUGATION.

Tense	Active			Passive		
	Indicative Mood.					
Present Tense.	S. Reg-o,	*I rule*		S. Reg-or,	*I am*	*ruled*
	reg-is,	*thou rulest*		reg-ĕris,	*thou art*	
	reg-it,	*he rules*		reg-ĭtur,	*he is*	
	Pl. reg-ĭmus,	*we rule*		Pl. reg-ĭmur,	*we are*	
	reg-ĭtis,	*ye rule*		reg-imĭni,	*ye are*	
	reg-unt,	*they rule*		reg-untur,	*they are*	
Imperfect.	S. reg-ēbam,	*I was*	*ruling*	S. reg-ēbar,	*I was*	*(being) ruled*
	reg-ēbas,	*thou wast*		reg-ebāris,	*thou wast*	
	reg-ēbat,	*he was*		reg-ebātur,	*he was*	
	Pl. reg-ebāmus,	*we were*		Pl. reg-ebāmur,	*we were*	
	reg-ebātis,	*ye were*		reg-ebamĭni,	*ye were*	
	reg-ēbant,	*they were*		reg-ebantur,	*they were*	
Perfect.	S. rex-i,	*I ruled*		S. rect-us sum,	*I was*	*ruled*
	rex-isti,	*thou ruledst*		rect-us es,	*thou wast*	
	rex-it,	*he ruled*		rect-us est,	*he was*	
	Pl. rex-ĭmus,	*we ruled*		Pl. rect-i sumus,	*we were*	
	rex-istis,	*ye ruled*		rect-i estis,	*ye were*	
	rex-ērunt,	*they ruled*		rect-i sunt,	*they were*	
Pluperfect.	S. rex-ĕram,	*I had*	*ruled*	S. rect-us eram,	*I had*	*been ruled*
	rex-ĕras,	*thou hadst*		rect-us eras,	*thou hadst*	
	rex-ĕrat,	*he had*		rect-us erat,	*he had*	
	Pl. rex-erāmus,	*we had*		Pl. rect-i erāmus,	*we had*	
	rex-erātis,	*ye had*		rect-i erātis,	*ye had*	
	rex-ĕrant,	*they had*		rect-i erant,	*they had*	
Future Simple.	S. reg-am,	*I shall*	*rule*	S. reg-ar,	*I shall*	*be ruled*
	reg-es,	*thou wilt*		reg-ēris,	*thou wilt*	
	reg-et,	*he will*		reg-ētur,	*he will*	
	Pl. reg-ēmus,	*we shall*		Pl. reg-ēmur,	*we shall*	
	reg-ētis,	*ye will*		reg-emĭni,	*ye will*	
	reg-ent,	*they will*		reg-entur,	*they will*	
Future Perfect.	S. rex-ĕro,	*I shall*	*have ruled*	S. rect-us ero,	*I shall*	*have been ruled*
	rex-ĕris,	*thou wilt*		rect-us eris,	*thou wilt*	
	rex-ĕrit,	*he will*		rect-us erit,	*he will*	
	Pl. rex-erimus,	*we shall*		Pl. rect-i erĭmus,	*we shall*	
	rex-eritis,	*ye will*		rect-i erĭtis,	*ye will*	
	rex-ĕrint,	*they will*		rect-i erunt,	*they will*	
	Subjunctive Mood.					
Present Tense.	S. reg-am,	*I may*	*rule*	S. reg-ar,	*I may*	*be ruled*
	reg-as,	*thou mayst*		reg-āris,	*thou mayst*	
	reg-at,	*he may*		reg-ātur,	*he may*	
	Pl. reg-āmus,	*we may*		Pl. reg-āmur,	*we may*	
	reg-ātis,	*ye may*		reg-amĭni,	*ye may*	
	reg-ant,	*they may*		reg-antur,	*they may*	
Imperfect.	S. reg-ĕrem,	*I might*	*rule*	S. reg-ĕrer,	*I might*	*be ruled*
	reg-ĕres,	*thou mightst*		reg-erēris,	*thou mightst*	
	reg-ĕret,	*he might*		reg-erētur,	*he might*	
	Pl. reg-erēmus,	*we might*		Pl. reg-erēmur,	*we might*	
	reg-erētis,	*ye might*		reg-eremĭni,	*ye might*	
	reg-ĕrent,	*they might*		reg-erentur,	*they might*	
Perfect.	S. rex-ĕrim,	*I may*	*have ruled*	S. rect-us sim,	*I may*	*have been ruled*
	rex-ĕris,	*thou mayst*		rect-us sīs,	*thou mayst*	
	rex-ĕrit,	*he may*		rect-us sit,	*he may*	
	Pl. rex-erimus,	*we may*		Pl. rect-i sīmus,	*we may*	
	rex-eritis,	*ye may*		rect-i sītis,	*ye may*	
	rex-ĕrint,	*they may*		rect-i sint,	*they may*	
Pluperfect.	S. rex-issem,	*I should*	*have ruled*	S. rect-us essem,	*I should*	*have been ruled*
	rex-isses,	*thou wouldst*		rect-us esses,	*thou w'ldst*	
	rex-isset,	*he would*		rect-us esset,	*he would*	
	Pl. rex-issēmus,	*we should*		Pl. rect-i essēmus,	*we should*	
	rex-issētis,	*ye would*		rect-i essētis,	*ye would*	
	rex-issent,	*they would*		rect-i essent,	*they would*	

FOURTH CONJUGATION.

Tense	Active			Passive		
	Indicative Mood.					
Present Tense.	S. Aud-io,	*I hear*		S. Aud-ior,	*I am*	*heard*
	aud-is,	*thou hearest*		aud-īris,	*thou art*	
	aud-it,	*he hears*		aud-ītur,	*he is*	
	Pl. aud-īmus,	*we hear*		Pl. aud-īmur,	*we are*	
	aud-ītis,	*ye hear*		aud-imīni,	*ye are*	
	aud-iunt,	*they hear*		aud-iuntur,	*they are*	
Imperfect.	S. aud-iēbam,	*I was*	*hearing*	S. aud-iēbar,	*I was*	*(being) heard*
	aud-iēbas,	*thou wast*		aud-iebāris,	*thou wast*	
	aud-iēbat,	*he was*		aud-iebātur,	*he was*	
	Pl. aud-iebāmus,	*we were*		Pl. aud-iebāmur,	*we were*	
	aud-iebātis,	*ye were*		aud-iebamĭni,	*ye were*	
	aud-iēbant,	*they were*		aud-iebantur,	*they were*	
Perfect.	S. aud-īvi,	*I heard*		S. aud-ītus sum,	*I was*	*heard*
	aud-ivisti,	*thou heardst*		aud-ītus es,	*thou wast*	
	aud-īvit,	*he heard*		aud-ītus est,	*he was*	
	Pl. aud-ivĭmus,	*we heard*		Pl. aud-īti sumus,	*we were*	
	aud-ivistis,	*ye heard*		aud-īti estis,	*ye were*	
	aud-ivērunt,	*they heard*		aud-īti sunt,	*they were*	
Pluperfect.	S. aud-ivĕram,	*I had*	*heard*	S. aud-ītus eram,	*I had*	*been heard*
	aud-ivĕras,	*thou hadst*		aud-ītus eras,	*thou hadst*	
	aud-ivĕrat,	*he had*		aud-ītus erat,	*he had*	
	Pl. aud-iverāmus,	*we had*		Pl. aud-īti erāmus,	*we had*	
	aud-iverātis,	*ye had*		aud-īti erātis,	*ye had*	
	aud-ivĕrant,	*they had*		aud-īti erant,	*they had*	
Future Simple.	S. aud-iam,	*I shall*	*hear*	S. aud-iar,	*I shall*	*be heard*
	aud-ies,	*thou wilt*		aud-iēris,	*thou wilt*	
	aud-iet,	*he will*		aud-iētur,	*he will*	
	Pl. aud-iēmus,	*we shall*		Pl. aud-iēmur,	*we shall*	
	aud-iētis,	*ye will*		aud-iemĭni,	*ye will*	
	aud-ient,	*they will*		aud-ientur,	*they will*	
Future Perfect.	S. aud-ivĕro,	*I shall*	*have heard*	S. aud-ītus ero,	*I shall*	*have been heard*
	aud-ivĕris,	*thou wilt*		aud-ītus eris,	*thou wilt*	
	aud-ivĕrit,	*he will*		aud-ītus erit,	*he will*	
	Pl. aud-iverimus,	*we shall*		Pl. aud-īti erĭmus,	*we shall*	
	aud-iveritis,	*ye will*		aud-īti erĭtis,	*ye will*	
	aud-ivĕrint,	*they will*		aud-īti erunt,	*they will*	
	Subjunctive Mood.					
Present Tense.	S. aud-iam,	*I may*	*hear*	S. aud-iar,	*I may*	*be heard*
	aud-ias,	*thou mayst*		aud-iāris,	*thou mayst*	
	aud-iat,	*he may*		aud-iātur,	*he may*	
	Pl. aud-iāmus,	*we may*		Pl. aud-iāmur,	*we may*	
	aud-iātis,	*ye may*		aud-iamĭni,	*ye may*	
	aud-iant,	*they may*		aud-iantur,	*they may*	
Imperfect.	S. aud-īrem,	*I might*	*hear*	S. aud-īrer,	*I might*	*be heard*
	aud-īres,	*thou mightst*		aud-irēris,	*thou mightst*	
	aud-īret,	*he might*		aud-irētur,	*he might*	
	Pl. aud-irēmus,	*we might*		Pl. aud-irēmur,	*we might*	
	aud-irētis,	*ye might*		aud-iremĭni,	*ye might*	
	aud-īrent,	*they might*		aud-irentur,	*they might*	
Perfect.	S. aud-ivĕrim,	*I may*	*have heard*	S. aud-ītus sim,	*I may*	*have been heard*
	aud-ivĕris,	*thou mayst*		aud-ītus sīs,	*thou mayst*	
	aud-ivĕrit,	*he may*		aud-ītus sit,	*he may*	
	Pl. aud-iverimus,	*we may*		Pl. aud-īti sīmus,	*we may*	
	aud-iveritis,	*ye may*		aud-īti sītis,	*ye may*	
	aud-ivĕrint,	*they may*		aud-īti sint,	*they may*	
Pluperfect.	S. aud-ivissem,	*I should*	*have heard*	S. aud-ītus essem,	*I should*	*have been heard*
	aud-ivisses,	*thou wouldst*		aud-ītus esses,	*thou w'ldst*	
	aud-ivisset,	*he would*		aud-ītus esset,	*he would*	
	Pl. aud-ivissēmus,	*we should*		Pl. aud-īti essēmus,	*we should*	
	aud-ivissētis,	*ye would*		aud-īti essētis,	*ye would*	
	aud-ivissent,	*they would*		aud-īti essent,	*they would*	

Note.—The imperatives, infinitives, gerunds, supines, and participles of these conjugations will be found on page 419.

	FIRST CONJUGATION. ACTIVE.	FIRST CONJUGATION. PASSIVE.	SECOND CONJUGATION. ACTIVE.	SECOND CONJUGATION. PASSIVE.
	Imperative Mood.		**Imperative Mood.**	
Pres.	S. am-ā, *love thou* Pl. am-āte, *love ye*	S. am-āre, *be thou loved* Pl. am-amĭni, *be ye loved*	S. mon-ē, *advise thou* Pl. mon-ēte, *advise ye*	S. mon-ēre, *be thou advised* Pl. mon-emĭni, *be ye advised*
Fut. Simple.	S. am-āto, *thou must love* am-āto, *he must love* Pl. am-atōte, *ye must love* am-anto, *they must love*	S. am-ātor, *thou must be loved* am-ātor, *he must be loved* — Pl. am-antor, *they must be loved*	S. mon-ēto, *thou must advise* mon-ēto, *he must advise* Pl. mon-etōte, *ye must advise* mon-ento, *they must advise*	S. mon-ētor, *thou must be advised* mon-ētor, *he must be advised* — Pl. mon-entor, *they must be advised*
	Infinitive Mood.		**Infinitive Mood.**	
Pres.	am-āre, *to love* or *be loving*	am-āri, *to be loved*	mon-ēre, *to advise*, or *be advising*	mon-ēri, *to be advised*
Perf.	am-avisse, *to have loved*	am-ātus esse, *to have been loved*	mon-uisse, *to have advised*	mon-ĭtus esse, *to have been advised*
Fut.	am-atūrus esse, *to be about to love*	am-ātum iri, *to be about to be loved, &c.*	mon-itūrus esse, *to be about to advise*	mon-ĭtum iri, *to be about to be advised, &c.*
	Participles.		**Participles.**	
Pre.	am-ans, *loving*	—	mon-ens, *advising*	—
Per.	—	am-ātus, *loved*	—	mon-ĭtus, *advised*
Fut.	am-atūrus, *about to love.*	am-andus, *meet to be loved*	mon-itūrus, *about to advise*	mon-endus, *meet to be advised*
	Gerunds. N. A. am-andum, *loving* G. am-andi, *of loving* D. Ab. am-ando, *for* or *by loving*	**Supines.** ACTIVE. am-ātum, *to love* PASSIVE. am-ātu, *to be loved*	**Gerunds.** mon-endum, *advising* mon-endi, *of advising* mon-endo, *for* or *by advising*	**Supines.** ACTIVE. mon-ĭtum, *to advise* PASSIVE. mon-ĭtu, *to be advised*

We have endeavoured in the preceding models of conjugation to present these paradigms at one view, so that the student may observe their general similarity, notwithstanding their apparent, but in reality very slight, orthographical differences.

It may be just as well to notice here, that this whole plan of the derivation of tenses is probably rather an ingenious contrivance of the grammarians than a genuine explanation of the ideal followed by those to whom the use of the language was natural. It is the more necessary to mention this because the supine, though always supposed to exist—as the formative element from which the participles are derived—really occurs very rarely. It is not therefore always safe in writing Latin to use the supine of verbs given in grammars and dictionaries, under the impression that we are conforming to classical usage; for grammarians give supines to a great many verbs, which yet are not to be found in any author, because the participles formed from them are found. Grammarians suppose likewise that all deponent verbs, of old, had the active voice, and consequently supines, though now they have lost them.

Deponent verbs (see p. 319) being in form passives, are conjugated like them, and conform to the four regular conjugations. Those whose roots—*i.e.* crude-form stems—end in *ā*, *ē*, and *ī* are of the First, Second, and Fourth Conjugations, and all the rest belong to the Third. But the conjugation of a deponent verb has a greater number of forms than an ordinary passive verb; for it has not only the supine and the gerund, but also four participles, viz.: (1) the *present* participle, as *hortans* (admonishing), denoting the action in progress; (2) the *perfect*, *hortatus* (having admonished), denoting the action as completed; (3) the *future*, *hortaturus* (about to admonish), describing an action as future; and (4) the *gerundive*, *hortandus* (to be admonished), which has a passive meaning, and accordingly is formed only from those deponents which have a transitive signification. In the neuter gender, however, the gerundive also occurs from intransitive verbs.

The following are examples of deponent verbs in each of the conjugations, viz.:—(1) *Prĕcor*, *prĕcāris* or *prĕcāre*, *prĕcātus sum* or *fui*, *prĕcāri; prĕcandi*, *prĕcando*, *prĕcandum; prĕcātum*, *prĕcātu; prĕcans*, *prĕcātūrus*, *prĕcātus*, *prĕcandus*, to pray. (2) *Mĕreor*, *mĕrēris*, or *mĕrēre*, *mĕrĭtus sum* or *fui*, *mĕrēri; mĕrendi*, *mĕrendo*, *mĕrendum; mĕrĭtum*, *mĕrĭtu; mĕrens*, *mĕrĭtūrus*, *mĕrĭtus*, *mĕrendus*, to deserve. (3) *Sĕquor*, *sĕquĕris* or *sĕquĕre*, *sĕcūtus sum* or *fui*, *sĕqui; sĕquendi*, *sĕquendo*, *sĕquendum; sĕcūtum*, *sĕcūtu; sĕquens*, *sĕcūtūrus*, *sĕcūtus*, *sĕquendus*, to follow. (4) *Partior*, *partīris* or *partīre*, *partītus sum* or *fui*, *partīri; partiendi*, *partiendo*, *partiendum; partītum*, *partītu; partiens*, *partītūrus*, *partītus*, *partiendus*, to divide.

EXERCISES ON THE CONJUGATIONS IN THEIR SIMPLEST AND MOST REGULAR FORMS.

(1) Instead of the letters *am* in the model of the First Conjugation introduce the italicized portion of the following verbs, and replace the word "love" in the translation by the word given as the meaning of the verb used, viz. *ăro*, I plough; *orno*, I adorn; *ōro*, I pray; *păro*, I prepare; *vīto*, I avoid; *jūro*, I swear; *lĭgo*, I bind; *rŏgo*, I ask; *voco*, I call; *numero*, I number or count; *gŭberno*, I govern; *muto*, I change.

(2) Replace the letters *mon* in the paradigm of the Second Conjugation by the letters in italics in the following verbs, and the word "advise" by the meaning here given to the verb used, viz. *hăb*eo, I have; *dēb*eo, I owe; *jub*eo, I order; *prœb*eo, I afford; *plac*eo, I please; *nŏc*eo, I hurt; *tac*eo, I am silent; *dŏl*eo, I grieve; *cal*eo, I am warm; *val*eo, I am well; *pār*eo, I obey; *mĕr*eo, I deserve.

(3) Supply the places of *reg*, *rex*, *rect* wherever they occur by the italicized portions of the following verbs, and the word "rule" by that given as the meaning of the verb used to

	THIRD CONJUGATION.		FOURTH CONJUGATION.	
	ACTIVE.	PASSIVE.	ACTIVE.	PASSIVE.
	Imperative Mood.		**Imperative Mood.**	
Pres.	S. reg-e, *rule thou* Pl. reg-ĭte, *rule ye*	S. reg-ĕre, *be thou ruled* Pl. reg-imĭni, *be ye ruled*	S. aud-ī, *hear thou* Pl. aud-īte, *hear ye*	S. aud-īre, *be thou heard* Pl. aud-imĭni, *be ye heard*
Fut. Simple.	S. reg-ĭto, *thou must rule* reg-ĭto, *he must rule* Pl. reg-itōte, *ye must rule* reg-unto, *they must rule*	S. reg-ĭtor, *thou must be ruled* reg-ĭtor, *he must be ruled* — Pl. reg-untor, *they must be ruled*	S. aud-īto, *thou must hear* aud-īto, *he must hear* Pl. aud-itōte, *ye must hear* aud-iunto, *they must hear*	S. aud-ītor, *thou must be heard* aud-ītor, *he must be heard* — Pl. aud-iuntor, *they must be heard*
	Infinitive Mood.		**Infinitive Mood.**	
Pres.	reg-ĕre, *to rule*, or *be ruling*	reg-i, *to be ruled*	aud-īre, *to hear* or *be hearing*	aud-īri, *to be heard*
Perf.	rex-isse, *to have ruled*	rect-us esse, *to have been ruled*	aud-ivisse, *to have heard*	aud-ītus esse, *to have been heard*
Fut.	rect-ūrus esse, *to be about to rule*	rect-um iri, *to be about to be ruled, &c.*	aud-itūrus esse, *to be about to hear*	aud-ītum iri, *to be about to be heard, &c.*
	Participles.		**Participles.**	
Pre.	reg-ens, *ruling*	—	aud-iens, *hearing*	—
Per.	—	rect-us, *ruled*	—	aud-ītus, *heard*
Fut.	rect-ūrus, *about to rule*	reg-endus, *meet to be ruled*	aud-itūrus, *about to hear*	aud-iendus, *meet to be heard*
	Gerunds.	**Supines.**	**Gerunds.**	**Supines.**
	N. A. reg-endum, *ruling* G. reg-endi, *of ruling* D. Ab. reg-endo, *for* or *by ruling*	ACTIVE. rect-um, *to rule* PASSIVE. rect-u, *to be ruled*	aud-iendum, *hearing* aud-iendi, *of hearing* aud-iendo, *for* or *by hearing*	ACTIVE. aud-ītum, *to hear* PASSIVE. aud-ītu, *to be heard*

replace these syllables, viz. *cing*o, *cinx*i, *cinct*um, *cing*ĕre, I surround; *dīc*o, *dix*i, *dict*um, *dic*ĕre, I say; *flig*o, *flix*i, *flict*um, *flig*ĕre, I strike; *fig*o, *fix*i, *fix*um, *fig*ere, I fix; *ping*o, *pinx*i, *pinct*um, *ping*ere, I paint; *frang*o, *freg*i, *fract*um, *frang*ere, I break.

(4) Replace *aud*, wherever it occurs, by the part of the following verbs given in italics, and the word "hear" by that given as the signification of the verb used, viz. *fin*io, I finish; *pun*io, I punish; *erud*io, I instruct; *dorm*io, I sleep; *nutr*io, I nourish; *bull*io, I boil; *mun*io, I fortify.

(5) Write out a complete paradigm in each conjugation, using the verbs given in the foregoing exercises in the order in which they occur in rotation, one for each tense.

(6) Commit to memory the paradigm tense by tense, and as each tense is learned repeat it with each of the above-given verbs through all the persons and numbers.

(7) Carefully inspect the following sentences, observing (1) the termination of the Latin verb, here italicized; (2) the translation given; (3) the similar terminations in the paradigms, with the translation given there; and (4) the person, number, tense, and mood which these terminations indicate.

1. Arm*at* (1) spina rosas. 2. Autumnus effund*it* (3) fruges. 3. Diem perdid*i* (3). 4. Aurum omnes cŏl*unt* (3). 5. Scipio Carthaginem dēlēv*it* (2). 6. Hostes non tĭm*emus* (2). 7. Romani loca superiora occŭp*ant* (1). 8. Demosthenes sæpe Platonem audi*ebat* (4). 9. Achæi auxilia Philippum or*abant* (1). 10. Discipulus linguam Latinam disc*et* (3). 11. Corvus centum annos viv*et* (3). 12. Somnium somni*avi* (1). 13. Te dŏc*ebo* (2) literas. 14. Non te sententiam cēl*abo* (1). 15. Iram qui vinc*it* (3), hostem sŭpĕr*at* (1) maximum. 16. Vili dŏmum vendĭd*isti* (3). 17. Facta ducum viv*ent* (3). 18. Tres uno pĕr*ierunt* (4) rhētŏres anno. 19. Effĭciendum est, ut appĕtītūs ŏbēd*irent* (4) rātioni. 20. Nĭhĭl dēspērandŭm [est] (1).

1. A thorn arms roses. 2. Autumn brings forth fruits. 3. I have lost a day. 4. Everybody desires gold. 5. Scipio destroyed Carthage. 6. We do not fear enemies. 7. The Romans occupy the higher grounds. 8. Demosthenes frequently listened to Plato. 9. The Achaians prayed for help from Philip. 10. The student will learn the Latin language. 11. The crow will live a hundred years. 12. I have dreamed a dream. 13. I will teach thee letters. 14. I will not hide my opinion from thee. 15. He who conquers wrath overcomes the greatest enemy 16. Thou hast sold thy house for a small sum. 17. The deeds of leaders shall live. 18. Three orators perished in one year. 19. It is necessary that the appetites should yield obedience to reason. 20. There is no need for despairing.

(8) Substitute such other parts of the several verbs as may make sense with the words given in any of the foregoing sentences: *e.g.* Scipio Carthaginem del*et*, del*ebit*, del*eat*, &c.

It is often found of great advantage, as an aid to the memory, to write out the crude-form portion of the present and perfect of the indicative mood, and that of the supine and infinitive, through all the parts of the verb in which they occur (as tabulated on p. 320 and given in a rhythmical rule on p. 321) in black ink, and thereafter to add on through each person and number in each tense and mood the proper terminational additions in red ink.

As the third persons of the verb are those most frequently met with in reading and required in writing, it is advisable to make a special point of knowing all these thoroughly. This may be very advantageously studied by writing down on a card the several terminations of the third persons singular and plural, in each conjugation, in red ink, and then taking any verb and running over the third persons of the conjugation of that verb till familiarity with and readiness in their use have been acquired; and we can, as the Romans did, mentally connect the meaning with the termination.

Again, it tends greatly to give command over the form and signification of verbs to write them out departmentally, as we may say—*i.e.* making the exercise consist in writing out in full all the parts of the verb derived from the root or crude form respectively of the present, the perfect, the supine, and the infinitive.

PHYSIOLOGY.—CHAPTER VI.

THE NERVOUS SYSTEM IN ITS HIGHER RELATIONS—GENERAL AND SPECIAL SENSATION — ORGANIC SENSIBILITY — THE ORGANS OF SENSATION: TOUCH, SMELL, TASTE, HEARING, AND SIGHT.

NERVES are organs of relation. The more perfect the nervous structure of a being is, the wider are the relations into which it can enter, not only of part with part, but also of the being with its surroundings. The characteristic of nervous tissue is sensibility. It receives, elaborates, and transmits impressions. Though the nerve-fibres seem much more readily to perceive a change in, than a permanency of, their state, yet they must be capable of appreciating the vital condition in which they subsist; that is, they must possess a tonic sensibility, a feeling of their uniform and steady general fitness for healthy activity, or the reverse. Upon the existence of such a susceptibility depends a great deal of our common ideal of ordinary bodily comfort, or our experience of personal discomfort when depressed and overcome by lassitude or ennui. The *vis nervosa*, or nervous energy, may be static as well as dynamic, though it is most usually in those vital actions and reactions of its force involved in the transmission of impressions, that we become aware of the sensibility the nerve-fibres possess. Ordinary language fails to express, because common experience fails to convey, in any concentrated form claiming a name, this undercurrent or subconscious condition of healthy nervousness. What one might call the organized consensuousness of individual life, and the co-ordinateness of the whole nervous energy implied in the perception of personal being, exhibit a nicely balanced correlation of nerve-structure which we feel as vitality and know as health.

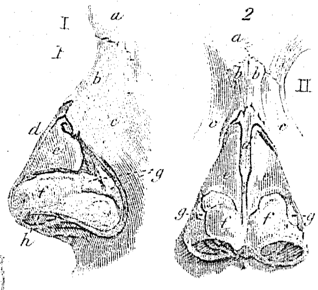
Living nerve is receptive, perceptive, and active. The relations of nerve-tissues to one another insure organic sensibility, which is the customary evidence of vitality, and is called common sensation—that general susceptibility to impressions which is inherent in nerves, and which manifests itself in all the parts of the body through which sensory nerves are distributed, and which is inextricably interwoven with their tissues. Most portions of the human frame have special forms of sensibility peculiar to themselves, which suggest the feeling of ease or uneasiness arising from the manner in which the organic functions are performing their duty in the upbuilding or conservation of the bodily organs. There are therefore what we may call the *digestive* sensibilities, such as hunger, thirst, nausea, repletion, and the sentiency of the alimentary canal; the *respirative* sensibility—the satisfactoriness or unsatisfactoriness of the breathing process, and organs employed in it, when the air inhaled is or is not supplied normally with its constituent elements, or the vital capacity of the lungs is or is not normal or in normal activity; the *circulative* sensibility, which, though vague in feeling and difficult to explain, certainly makes itself manifest in languor and depression, or in a genial glow of serene and quiet contentment; the sensibility of *temperature*, felt when the equability of the outer and inner heat are in harmony, and the sensory powers are all so uniformly and gratifiedly exerted as to give the impression of comfort; and *muscular* sensibility, such feelings as arise from impressions of equilibrium, resistance, weight, strain, and the like, which are communicated to the sensitive filaments of the nervous system. This common sensation, which might almost be regarded as the passive, unexcited, static condition of the nervous system, cannot be unattended with feeling, must constitute portion of our experience, and may be regarded as possessing a well-defined and distinct range of sensibility not customarily taken into account in our consciousness, though quite capable of being brought within its ken when the normal state begins to give indication that change is occurring. The sense of vigour or of *malaise*, of latent power or of infelt faintness, are facts which seem to prove that common sensation, or the inward feeling of fitness for work and capacity for stimulation, which we usually call the tone of the system, is one of the powers of the nervous tissues; that there is, as it were, a vital health-point in each person which requires to be kept up, and which, when wanting, is "failure of nerve," and which, when unduly superabundant, constitutes "nervousness." If the organic condition of the nervous tissues is normal, no noticeable consciousness of their existence and action is, as a general rule, felt; but any deficient supply of nervile force, or any superabundance of it, as well as all measurable changes occurring in it, communicate to the nerve-centres, or the sensorium, those general impressions of fulness or want, of healthy or unhealthy state, &c., which constitute common or general sensation.

TOUCH.

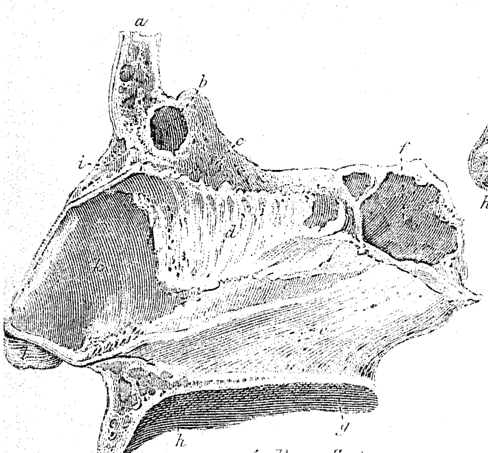
THIS is the most simple and generally diffused of all the special sensations—the least complex, not only in its mechanism, but in its impressions. It has its seat in the whole of the skin, and in certain parts, as the interior of the mouth, supplied with a mucous membrane. Its mode of action, by contact and pressure, makes its operation exceedingly simple. Yet it is a sense which conveys to the mind a large number of important impressions and conceptions—*e.g.* form, size, direction, distance, position, movement, force, &c. Each little space in the surface of the skin has a separate nerve in it, and a distinct communication with the nerve-centres concerned in touch, which, after patience and practice, enables us to localize impressions and refer the sensations we experience to the spot at which contact has taken (or is taking) place. The objects of *touch* are chiefly the surfaces of solid substances. Neither gases nor liquids affect the tactile nerves much. Even equal pressure and perfectly smooth bodies do not stimulate the touch greatly. The roughnesses of and the changes in the things felt quicken the special sensibility of touch most influentially; the nature, properties, and constituent parts of the skin have already been explained in Chapter II. p. 129. We are here only concerned with the tactile properties of the skin, which throughout its entire extent is endowed with sensibility of touch. The tactile papillæ of the corium form prominences which are more or less thickly covered by the layers of the epidermis and the nerves which enter into the tissues of the corium, and the epidermis receives the tactile impressions which bodies yield. The nerves of touch are—for the trunk and limbs, the posterior roots of the spinal nerves, and for the head, face, mouth, tongue, &c., the fifth pair of the cerebral nerves proceeding from the gray substance of the floor of the fourth ventricle, and issuing from the cranial mass in from seventy to a hundred nerve-filaments. These an object placed in contact with the skin compresses. The more lightly the impact is made the greater the sensitiveness evoked. Intense pressure deadens the tactile power, lessens the conductile capacity of the nerves, and makes itself felt rather as resistant force than touch. Sensations of softness arise from the gentle contact of an extended surface with the nerve-filled skin. Pungency and pain make themselves felt when we have intense impressions made on small areas of surface. Sensations of slight, rapid, frequently changing, but constantly repeated touch, produce the sense of tickling, are capable of exciting slight laughter or of deepening into intense uneasiness and pain; those of damp adhesiveness excite a feeling of clamminess. Wetness and dryness appear to be sensations of touch, while those of temperature seem to be results of common sensitiveness. Articulate discrimination exercised by the sense of touch leads to distinguishable impressions of points, and therefore of number, position, distance, roughness, &c. The sensibility to weight, hardness, elasticity, consistence, pressure, &c., is probably a compound result of touch and muscular experience. Form arises as a compound ideal, as perhaps extension also does, when it projects itself as space, movement, friction, &c. Touch is culturable, and is one of the main agencies man employs in handicraft labour, and in industrial pursuits or artistic manipulation. In these occupations, man requires to graduate and regulate by touch the power and effort of his hand, so as to use only such force as is needful in such manner as is best. Hence, any characteristic manner of doing anything with the hand—*e.g.* the fingering of the keys of a piano—is called "the touch," while to preserve the closest and most direct relation of ourselves with the events of our day is denoted by saying we "keep ourselves in touch" with the times. Of the skin, as adapted for furnishing perceptions of touch, almost enough has been already said on page 130. We may only here note that Wagner's theory of touch is that within the papillæ of the

PHYSIOLOGY.

ORGANS OF SMELL & TASTE.

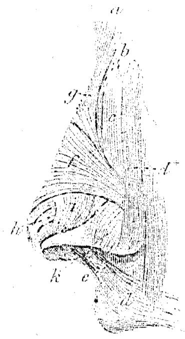


1–2. Fibro Cartilages of Nose.

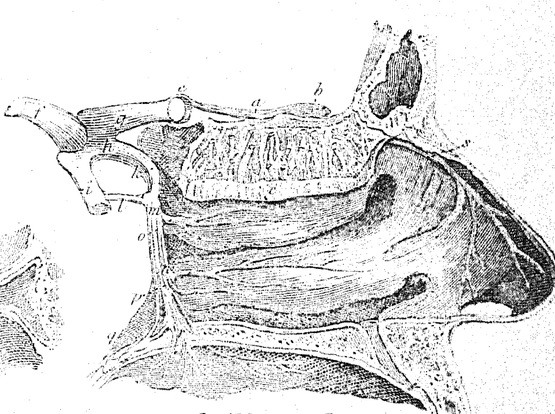


4. Bony Septum.

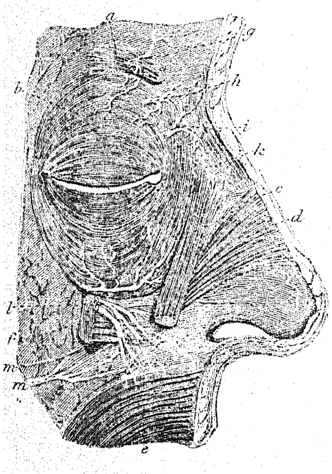
5. Turbinated Bones.



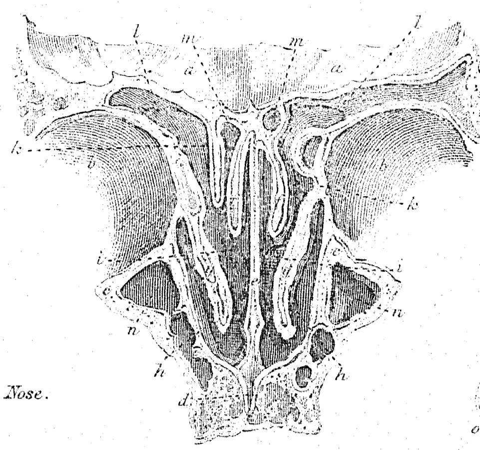
3. Muscles of the Nose.



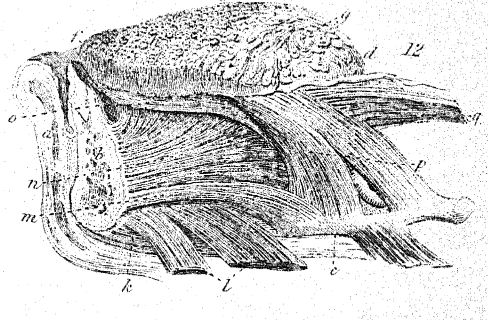
7. Olfactory Nerve.



8. Muscles and Ordinary Nerves of the Nose.



6. Section through the nasal cavity.



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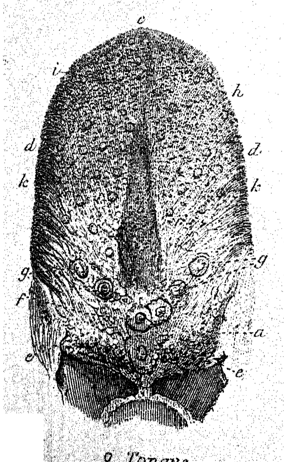
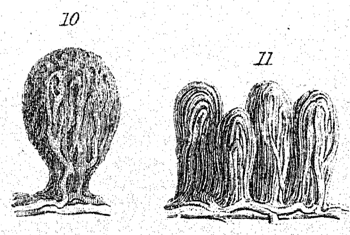
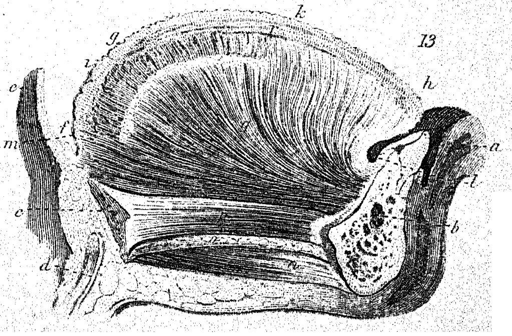


9. Tongue.



10–11. Papillæ of Tongue.



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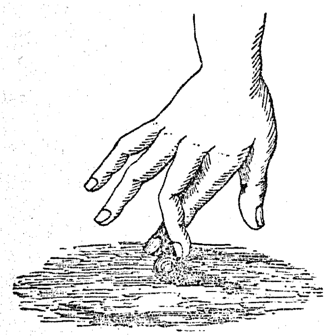
cutis vera there are distinct touch-corpuscles, consisting of a firm nucleated core, round which the nerves are coiled; and Krause maintains that in or beneath the papillæ, where the skin is very delicately textured, there are minute end-bulbs of nervous tissue which communicate sensations derived from specially slight contact. There can be no doubt that the nerves of touch, so far as their special functions are concerned, as they are found at different depths in the adipose subcutaneous tissues of the frame, and are of different descriptions, are adapted in particular parts for special functions, and differ in fineness of texture and peculiarity of sensitiveness in different persons.



The sense of touch is subject to illusions or delusions of an extraordinary kind, which cannot be corrected even by the sight. The following one attracted the attention of Aristotle. Though so early observed, it has not to this day been fully explained. If we place on a table, or on the palm of the hand, a marble or any other small globular body, and holding it with the fore and middle fingers, crossed alternately, so that the marble shall only touch the outer surfaces of the two fingers, we will believe that we touch two marbles though we know that only one is present.

SMELL.

The nose, externally, presents the appearance of a projecting triangular pyramid-shaped organ, occupying the space in the front of the face which extends from the forehead, at a point between the eyes, to the commencement of the upper lip. This does not include all the structures required for the reception and perception of smell. The more important and essential portions are placed more deep-seatedly in a cavity formed within the bones of the face, above the organ of taste and at the entrance of the air-passages. These internal parts consist of two chief cavities, called the nasal *fossæ*, separated from one another by a vertical septum, and subdivided by spongy turbinated bones, projecting from the outward wall of the face, into three *meatus* or passages, which communicate by narrow apertures with various *sinus* or cells in the ethmoid, sphenoid, frontal, and upper maxillary bones.

We proceed to supply the student with a more specific technical description, which he should peruse carefully, following each indication on Plate XI. On this fig. 1 shows in profile the bones and fibro-cartilages of the nose—viz. *a*, the eyebrow; *b*, the nasal bone; *c*, the nasal process of the upper maxillary; *d*, *e*, *f*, and *g*, cartilages of the septum, side, alæ, and sessamoid; *h*, a nostril. Fig. 2 exhibits a front view of the same parts, and fig. 3 represents the muscles—viz. *f*, the compressor naris; *g*, the pyramidales; *h*, the little compressor; *i* and *k*, levatores alæ; *d**, orbiculares; *d* and *e*, naso-labials. In fig. 4 we see the bones of the nose: *a*, frontal; *b*, frontal sinus; *c*, the ethmoids; *d*, septum; *e*, vomer; *f*, sphenoid; *g* and *h*, palatals; *i*, nasals; *k*, cartilaginous septum; *l*, the nose-tip. We look, in fig. 5, at the left side in profile: *a*, frontal; *b*, ethmoid; *c*, *d*, sphenoid and its sinus; *e*, nasal; *f*, the external nose; *g*, *h*, the palatal floor; *i*, *k*, eustachian tube; *m*, *n*, turbinated and lachrymal bones. Fig. 6 is a frontal section, both nostrils being cut straight down just about the middle of the organ, though a little further forward on the right than on the left: *a*, *a*, ethmoid; *b*, *b*, orbits; *c*, *c*, antrum; *d*, hard palate; *e*, vomer; *f*,*f*, superior turbinate; *g*,*g*, inferior turbinates; *h*,*h*, *i*,*i*, *l*,*l*, meatus (passages); *k*,*k*, middle turbinates; *n*,*n*, cheek-bone sinus. In fig. 8 we have the outer ordinary sensory and motor nerves presented: *a*, *b* show how the great muscles of the eyebrow and eye are brought into play; *c*, *d*, nasal nerve; *e*, nerves moving muscles of the mouth; *f*, naso-palatal; *g*, supra-orbital nerve; *h*, *i*, *k*, supra-trochlear (fifth) nerve; *l*, infra-orbital; *m*,*m*, facial. The special nerves of smell appear in fig. 7: *a* is an olfactory peduncle, broadened into a bulb at *b*; thence the nerve filaments pass through the ethmoid *d*, to ramify externally on the turbinated bones and internally upon the septum, while the ordinary sensory nerve passes through the cribriform plate at *s*; the spheno-palatal ganglion is seen at *m* sending branches at *o* and *p* to the superior and inferior turbinate bones, and passing on to *r* to ramify over the palate. The olfactory nerve leaves the cavity of the skull by three roots, viz. (1) the inner, or short; (2) the middle; and (3) the outer, or long root. These three roots having united pass forward to, and rest on, the cribriform plate of the ethmoid, where they appear as the olfactory bulb (fig. 7, *b*). From the under surface of this *bulbus olfactorius* the distribution of its branches is given off. They pass in three groups through the cribriform plate of the ethmoid to supply the lining of the nostrils (*nares*). On the upper part of the septum, the inner of the three groups is distributed in dense masses and tufts; the middle group supplies the roof of the nasal fossæ on the under side of the cribriform plate; and the outer group are distributed upon the upper and middle turbinated bones. All the surfaces within the nose are coated over with a thin, tough, highly vascular, delicate membrane, whose structure is simple—though consisting fundamentally of the same integumentary character as the skin—possessing neither papillæ, cilia, nor glands, but which keeps itself continually moist by secreting in every part a clear, viscid, slightly saline mucus (fluid). The other portions of the mucous lining of the nose receive their nervous supplies from the fifth pair of the cerebral nerves. The narrow space which lies between the septum and the upper and middle turbinated bones constitutes the proper chamber of olfactory sensation, and is supplied by the first pair. When substances are presented to the nose, the air which is passing through the nostrils carries the odoriferous emanations into contact with the filaments of the olfactory nerves lining the nasal chambers, and so bring the possibility of sensory impressions within reach of the nervous centres. The condition necessary to the perception of odours is that the scented particles come into contact with the surface under which the olfactory nerves lie distributed. There is probably some chemical action in operation to excite sensations of smell, and it is essential that the odorous particles be transmitted to the nasal *fossæ* by a respiratory current so as to cause their impingement on the proper nerves. The perception of odours by nerves having a special function, different from the common and general function of irritability, constitutes the sense of smell, one of peculiar sensation forming a member of a special class.

TASTE.

The tongue is the organ of taste, and the seat of its sensibility is the mucous membrane which covers its surface. The anterior portion of the tongue is chiefly supplied with nerves of touch; the special nerves of taste are distributed in the posterior part, *i.e.* in or near the root of the tongue (Plate XI. fig. 9, *e*, *e*), along its edges (*k*, *d*, *h*), and near its tip (*c*). The upper surface of the tongue is covered with projections (*papillæ*), either simple or compound. The former nearly resemble those of the skin, and are distributed over all those parts where the latter are not found, and they also enter into the formation of the compound papillæ. These latter are of four sorts, (1) circumvallate or calciform, (2) fungiform, (3) conical, and (4) filiform. All these are richly served with a network of capillaries and nerve-fibres which enable them to exert their tactile and gustative functions (*a*, *b*, *c*). The circumvallate *papillæ* are found on the back part of the tongue (*f*, *g*), arranged in two rows like a V. They are highly vascular and sensitive prolongations of the mucous membrane, which are penetrated by nerve-tubes. They appear to secrete mucus besides imparting gustative impressions. They consist of a central, circular, flattened projection surrounded by a ring. The fungiform *papillæ* (fig. 10) are narrower at their base than at their top, and are covered with secondary simple *papillæ*. They are distributed over the space in front of the calciform circumvallated tissues, and their *epithelium* or investing integument is exceedingly thin. Hence they look red, because the circulating blood is but thinly veiled from sight. The conical *papillæ* (fig. 11) do not present this red-

dened appearance. Their processes are long and pointed. The filiform papillæ have a thicker epithelium, have a hair-pencil-like appearance, are partially mobile, and occur isolatedly here and there. It is probable that these latter two, from their being more developed in the portion of the tongue most employed in the movements requisite for mastication, have more to do with the directing of the muscular mechanism and of the material subjected to trituration than with the production of gustatory sensations. The extreme thinness of the investuring skin of all these *papillæ* make the stimulation of the nerve fibres by the sapid substances dissolved in the mucous membrane easy, for the contact of bodies in a liquid state and in motion seems to be essential to true gustative impressions. The gustative perception is probably the result of the stimulation of the nerves by a chemical action upon the surface of the tongue affecting the tissues of the nerves. Sapid substances liquefied not unfrequently give off odorous matters at the same time, so that we have a simultaneous stimulation of the olfactory and the gustatory nerves. When the latter alone are excited we perceive *savour*, when both *flavour*.

Some gustative sensibility is manifested by other parts than the surface of the tongue. The soft palate and uvula, the palatal arch, and the fauces are found to be capable of taste, though their perceptions are less delicate and rapid. Hence the determination of the precise seat of the true sense of taste, and the question of the sources of the nervous fibres, have led to much discussion. We aim at a popular statement, and it appears to us to be generally accepted, that the third division of the fifth nerve has a threefold task: (1) it is one of the special nerves of taste; (2) it supplies common sensation to the tongue, and, in addition, to the skin of the temples, the outer ear, the lower portions of the face, &c.; and (3) it provides the power required for mastication to the chief muscles employed in that function, except the buccinator. The glosso-pharyngeal nerve, through its two lingual branches distributed to the sides and root of the tongue, and perhaps its tonsilitic *plexus*, also imparts a large proportion of taste-perceptive nervous fibre. Some physiologists grade the papillary sensibility of the tongue and its co-agents into a threefold range, (1) touch, (2) taste, and (3) relish, as mere sensational pleasure or pain, as a combined result of sensational excitement and alimentary acceptability, or the reverse. The chief sensations of taste are acridity, astringency, fieriness, salinity, acidity, alkalinity, sweetness, bitterness, relish or *goût*, and disgust.

The uses of taste, besides its being a source of enjoyment, are to excite the flow of the saliva and mucus which are to prepare the food for the stomach, and to inform us of qualities in the objects which excite it, which bear a certain relation to their salubrity and digestibility.

The tongue consists of two lateral portions, which are symmetrical. Its form is triangular, being broad at its base, where it is connected by a continuous mucous membrane to the palate and epiglottis, and by several pairs of muscles to the *os hyoides* and lower jaw (as shown in figs. 12, 13, Plate XI., the former being a side view and the latter a vertical section of the tongue and lower jaw). The mass of the tongue is made up of the muscles which move it. They consist of the following pairs:—The *stylo-glossus*, which draws the tongue back; the *hyo-glossus*, which depresses the side of the tongue; and the *genio-hyo-glossus*, which renders the tongue concave, and projects and depresses its point. Several other muscles connected with the *os hyoides* and lower jaw act indirectly on the tongue. The accompanying figure will give a sufficiently accurate idea of the larger muscles and nerves composing the bulk, the general form, and the connections of the organ.

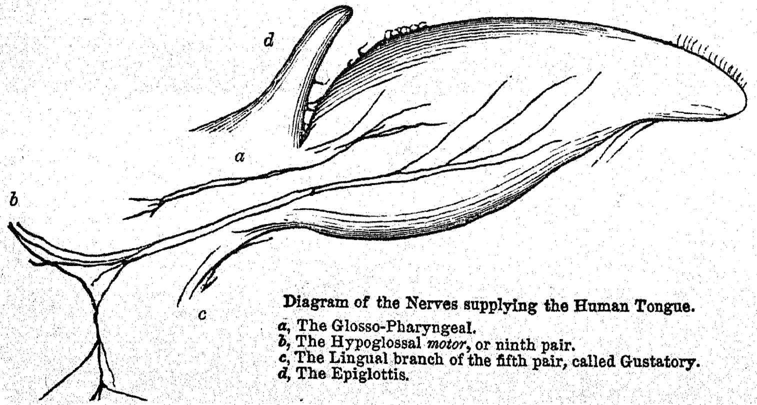


Diagram of the Nerves supplying the Human Tongue.
a, The Glosso-Pharyngeal.
b, The Hypoglossal *motor*, or ninth pair.
c, The Lingual branch of the fifth pair, called Gustatory.
d, The Epiglottis.

HEARING.

The ear, which is the organ of *hearing*, is a much more complex instrument than it might at first sight appear. As a sensory organ it may be regarded as consisting of two parts, (1) a conducting, and (2) a perceptive part. The first portion of the apparatus comprises five distinctly marked parts: (1) the pinna, auricle, or concha—*i.e.* the broad piece of elastic cartilaginous flesh attached to the side of the head and having the form of the lower part of an air-funnel, which is in ordinary language called the ear, and has for its purpose the reception, condensing, and intensification of the vibratory waves entering into it. In Plate XII. fig. 1, *a* is the helix, *a'* the notch, and *e*, *k* the fossa of the helix; *d*, *f*, the antihelix, and *l*, its fossa; *m*, the concha proper; *g*, *h*, tragus and antitragus; figs. 2, 3 give the muscles of the pinna as follows:—*a*, attollens auriculæ; *b*, attrahens auriculæ; *c c*, retrahentes auriculæ; *d*, Helicis major; *e*, Helicis minor; *d* (fig. 3) transversus auris. (2) The auditory meatus (canal) or outer tube of the ear, leading from the auricle to (3) the tympanum or drum-head, a delicate membrane stretched obliquely across the auditory opening, thus preventing any communication, through this opening, between the outer air and the drum. Of this fig. 4 supplies a view of the right labyrinth, the cochlea removed and the vestibule thrown open; fig. 5 a shallower section through the cochlea; fig. 6 a mould of the same part, in which *a* shows the vestibule, *b* fenestra ovalis, *c* cochlea, *g* its summit, *d*, *e*, *f* the upper, lower, and exterior semicircular canals. Fig. 7 is a section of same part. (4) The tympanic cavity or middle ear, which lies behind the drum-head, is about a bean's size, is filled with air, and contains (5) the three ear-bones or auditory ossicles—viz. the *stapes* or stirrup, *malleus* or hammer, and *incus* or anvil, which lie within the tympanic cavity, and are united by little joints permitting of motion among themselves. Fig. 8 indicates, at A the hammer, D the stirrup, and B the anvil, and at C the os orbiculare; *a b* is the head, *c* the long process, *d* the short process, *e* handle of hammer, *f* body, *g* short and *h* long process of anvil, *i* head, *l k* limbs, and *m* foot of stirrup; and fig. 9 represents them in position (*a* being the hammer, *d* the anvil, and *e* the stirrup resting on the fenestra ovalis, *h* vestibule, *i* first turn of the cochlea, *k* mastoid cells). These various co-operating parts receive and convey the vibrations which constitute sound into the inner ear.

The second constituent portion is the inner or perceptive ear. It is placed in direct communication, by the nerve of hearing, with the brain. This inner ear, to which the vibratory waves of air have been conveyed, is a delicate but complex structure. It consists of a series of differently shaped cavities chased out of part of the temporal bone, one of the hardest in the body—on which account it is called *petrosal* (rocky) (fig. 9, *b*, *g*, *k*). These communicate with the middle ear by two small *foramina* (openings), one oval and one round. Into the membrane which covers the oval aperture the foot of the *stapes* is fixed. The petrosal cavities are three in number: (1) the vestibule or entrance *h*, (2) the *cochlea* or snail-shell bone (fig. 10), and (3) the semicircular canals, of which there are three, the front vertical, the hinder vertical, and the horizontal.

lying almost at right angles to each other. The membranous labyrinth is filled with a fluid called the perilymph, such as exists in the brain, and upon the walls of this membrane the ultimate filaments of the auditory nerve are distributed. In the interior of each membranous *sac* there are certain small mobile hard bodies, called *octoconia* or ear-sand, consisting of crystals of carbonate of lime which, when moved by the beating of the waves of the fluid caused by the vibratory impulse communicated from without, knock against the delicate nervous tissues and awake the sensation of sound. The vibration or oscillation of the outward airy waves transmits their influences to the labyrinthine fluid or endolymph, and moves them along the surface of the auditory nerve. When, on the occurrence of a shock, excessive pressure is put upon the fluid of the labyrinthine cavity, the membrane of the oval aperture bulges out and allows the force of the rebound to be evaded, that the shock may be borne without injury to the inclosing membranous sac. Under ACOUSTICS the principles which regulate the perception of sound will be explained; but physiologists are, as yet, unable to supply from their knowledge of the science an explanation of the reason for the organs of hearing being composed of structures so heterogeneous, or of the mechanism which regulates the sensation of sound, and enables the organ to apply a phonometric measure to the intensity and height of sounds. All normal ears are sensitive to the quality, quantity (or volume), and intensity of sounds; most possess the specific susceptibility to pitch which forms the basis of music, and may acquire, more or less accurately, by experience and habit, perceptions of the articulateness, distance, and direction of sounds. Sounds, in quality, vary from sweet, rich, and mellow, to harsh, grating, and dissonant; in quantity, mass, or volume sound indicates the surface-extent and amount of the matter from which sound issues; in intensity we remark the difference between loudness and lowness in gentle and moderate tones, and those which come with smart pungency upon the ear. Suddenness generally adds the feeling of acuteness to a sound. Pitch indicates the rate of the vibrations of a sounding body. A musical note is a sound of uniform pitch, as is explained in MUSIC (p. 175). Hence we have perceptions of harmony and discord, of the qualitative difference of sounds, called *timbre*. The discrimination of articulate sounds depends on our sense of pitch. Sensibility to distance as regards sound is a product of observant experience, as are also our perceptions of direction and duration, which are compounds of auditory sensations with mental operations. Perceptions of ringing in the ears, buzzing, humming, ticking, &c., and of the real or apparent externality of sound, are mainly subjective, not objective impressions. The seventh pair of nerves consists of two distinct cords—(1) the *portio dura* or facial nerve, small, dense, and lying towards the interior; and (2) the *portio mollis*, soft, pulpy, and external. They are found side by side on the border of the *crus cerebelli*, and the latter may be traced from the transverse lines of the floor of the fourth ventricle. A few fibres are received from the rectiform body, and it is said to be connected with the gray matter of the *medulla oblongata*. It enters along with the facial nerve into the *meatus auditorius internus* (the inner auditorial passage), at the bottom of which it divides into the cochlear and vestibular branches. The former, in two divisions, forms a network of nerve filaments which come into peculiar relations with the epithelial lining, and some of them are said to terminate in certain rod-like bodies, called the fibres of Corti, in the scala media of the cochlea. The latter divides into three branches, of which the *superior* is distributed to the superior depression and the external semicircular canals; the *middle* passes through the hemispheric sac of the labyrinthine membrane; the *inferior* is distributed to the *ampulla* (end) of the posterior vertical semicircular canal. The details are too minute and intricate for popular exposition. Let it suffice to say that "ear-gate" is a most carefully constructed and well-protected organ, deserving rightly to be regarded as one of the most important. Touch and taste bring us into relation with things around us. Hearing introduces us into relationship one with another. Sonority in things and creatures communicates information and sensational experience; but the human voice is the counterpart of the human ear—the one is fitted to the other, and this mutual relation makes social life possible, and brings us within the range of the transmission of thought. The intricacy of the anatomy of the ear is only an indication of its immense value, and the necessity for taking care by cleanliness and culture to keep it healthy and make it useful.

SIGHT.

The eye, for the extent, variety, and rapidity of the information it communicates, is unrivalled among the senses; but it is more wonderful still for the structural adaptations it displays. It is a very perfect optical instrument, finely organized and delicate in texture It consists of a hollow ball or globe composed of three coats—(1) the sclerotic, (2) the nutritive, and (3) the retina—each different in structure and purpose. The sclerotic is thick, tough, and elastic. It forms, with the cornea which joins it, a protective cover to the whole mechanism, and imparts its fine white colour to the organ. Within the *sclerotic* (dense) layer lies the *choroid* or nutritive coat, intricately ramified through its whole tissues with bloodvessels for the nourishment of the tissues of the eye and the supply of its waste. It is stained of a deep brown colour by the animal paint or pigment which lines and darkens the interior of the eye, and absorbs those rays of light which, if they were to pass through the innermost coat, would blur and confuse the vision. The *retina* is the net-like nervous or sensitive coat, composed of an expansion of the optic nerve, on the delicate structures of which impressions are formed, and are thence transmitted to the brain. The *cornea* may be called the window of the eye, admitting the passage of the rays of light into the interior. It is an exquisitely clear, transparent, yet firm material, which replaces the opaque layer of the sclerotic just in front of the eye, which serves as a wall to contain the humours of the eye, and to give the rays of light admission to them. Behind it, acting as the curtain of the window, is the bright and variously coloured *iris*, a thin circular membrane having in its centre an aperture which, by the action of the iris, enlarges or contracts so as to regulate the amount of light permitted at once to enter the interior. One set of muscular bands, like the strings round the mouth of a bag, draw in its edges and lessen its size; while another, radiating from the centre, like the spokes of a wheel, by their contraction draw out the edges and increase the size of the pupil. In Plate XII., fig. 12, *a* is the optic nerve, *b* sclerotic, *c* cornea, *d*, choroid, *f* the ciliary body, *h* ciliary processes, *i* iris, *k* aqueous humour, *l* vitreous humour, *m* retina, *o* crystalline lens. The more minute details indicated by the lettering may be found serviceable in pursuing researches further than can be done in an outline so restricted as the present. In Fig. 13, *e* is the pupil, *d* iris, *b* ciliary processes, *c*, *c*, *c* border of retina, as seen from behind. Fig. 14 shows a front view of the same. Behind the iris is the crystalline lens *o* (fig. 12), a rounded transparent substance inclosed in a close-fitting capsule or shell, like a clear magnifying glass, which is capable of movement so as to change the focus of the eye and adapt it to the requirements of distinct vision. It may be made microscopic or telescopic according to need. Betwixt the cornea and the lens there occurs the aqueous or watery humour, a fluid differing little in composition from pure water; and the space behind the lens is occupied by a thin, clear, colourless, jelly-like matter called the vitreous (glassy) humour. The muscular mechanism by which the eye is moved has been already described, and is exhibited in fig. 15, in which *a* is the eyeball, *b levator palpebræ superioris*, *c levator oculi*, *e depressor oculi*, *f adductor oculi*, *d abductor oculi*, *g obliquus inferior oculi*; but there are still a few structures which, though not constituting parts of the eye proper, are of great importance to its usefulness and preservation. The eye being exposed to the action of irritating substances, as dust, the transparency of its clear window-like aperture would soon be obscured if it were not covered, protected, and able to be cleansed. The eyelids protect it from the access of light while we are asleep, forming moving shutters over them, and while opening and shutting cleans them with the help of that moisture which keeps them soft and smooth while it aids the eyelids

to pass without friction over the surface. They also direct the watery fluid which forms tears into their proper channels. The fringe of the eyelid preserves the eye from the intrusion of small insects or objects flying in the air, while, on the inner surface of the lids, certain glands secrete a greasy unguent which prevents the tears, unless under the stimulant of strong emotion, from overflowing the edge of the lid and running down the cheek. In fig. 18 the eyelids, *a*, *b*, are seen; *c*, orifice of the Meibomian glands; *d*, caruncle of the inner canthus. Fig. 17 shows the orbits, with their ciliary and tarsal margins: *a*, *b*, *e*, *f*, *g*, *h*, the lachrymal ducts; *i*, the head of the lachrymal sac; *k*, the lachrymal canal; *d*, the lachrymal lake; *c*, the emunctories.

Such is the outward apparatus of vision as a living optical instrument, a globular mass imbedded in a cushion of fat which lines the cavity of the orbit, moved and managed by an admirable muscular mechanism, and served by the optic nerve attached to it almost like an elastic handle. From the orbit of each eye the optic nerve (*f*, fig. 16) passes backwards through a special aperture into the cavity of the skull. At this point the two nerves cross, unite, and form an azygos, or single middle piece—the chiasma or optic commissure—after which the two nerve-trunks again separate and take their way now as flattened bands to the brain, along the optic tracts surrounding the *crus cerebri* and passing on to the optic thalamus. The optic nerve consists of numerous independent fibres which maintain their distinctness all the way into the brain, and are capable of carrying specific impressions to the centres of perception.

The optic nerve is susceptible to the play of light. [In NATURAL PHILOSOPHY the laws of light will be explained.] Perfect vision requires a sufficiency of light, so as to afford a correct image of objects on the retina. This makes demands for singularly minute subdivisions in the retina capable of independent sensation. This power of minute observation is confined to a very small portion of the retina, sometimes designated the yellow spot, the area of distinct vision. The eye, however, can adapt itself to vision at various distances. Though we have two eyes they present us, in a healthy condition of the organs, only with single vision, and though the objects mirrored in the eye are inverted in the image formed on the retina, the impression furnished to the perception is that of things upright. They are co-ordinated in their passage to the cerebral sensorium.

The eye yields us sensations of light and shade; makes us acquainted with the science, effects, and various phenomena of colour; and induces in us a sense of lustre. It greatly aids us in forming conceptions of externality, form, motion, distance, dimension, volume, solidity, proportion, position, &c. By the eye, indeed, Nature is made to us a book comprising more surprising and profound lessons than any book can ever contain. It transforms reality into pictures, and enables us to perceive the reality and beauty of drawing, painting, and art-work of all kinds. It makes known to us the largest alphabet of knowledge, life, and emotion, and it enriches the mind with the highest and best of all possible reproductions of human experience. It illumines creation for us into experience, science, poetry, and joy.

The nerves, as the sensitive material of the frame which brings us into relation with the outward world, with one another, and with other living creatures, constitute the interpreters to the consciousness of our own physical condition and our wants or joys; of the phenomena of nature, and the curiosities it inspires; of the feelings originated in us by the animal and vegetable creation; of the living sympathies excited in us by the fellowships and friendships of the world. By the nervous system we are made possessors of those perceptions which give us a conscious place among the products of creation, and a task to do in the world—namely, to live to good purpose for ourselves and others.

BOOK-KEEPING.—CHAPTER V.

BUSINESS BOOKS AND THEIR USES—BILL BOOK, INVOICE BOOK, AND JOURNAL.

THE primary records of business transactions are the Cash Book, Sales Book, and Day Book, the nature and form of which we have explained and illustrated. We have also indicated that many subsidiary books may be used, such as Petty Cash, Warehouse, Stock, Order, Invoice Books, &c. In the Cash Book and its auxiliaries, all cash, *i.e.* actual moneys received or paid, are entered and so accounted for. The Day Book and its adjuvants supply a register of all credit transactions—purchases, sales, and all charges, commissions, &c., which arise as concomitants. From these books the book-keeper can form a clear, succinct *vidimus* of the business, ready for examination and inspection at any time. In order to enable him to accomplish this with desirable precision, there is a book employed in every important business, into which all the daily transactions registered in the several books are collected with regularity and in order. This book is called "The Journal," and as the late F. H. Carter said, "constitutes and perfects the system of double entry."

Before proceeding to deal with journalizing, we had better draw the student's attention here to two subsidiary books of great importance in business—viz. the Bill Book and the Invoice Book.

Traders are in the habit, in the course of business, of giving and taking *bills*. A bill is a formal written engagement that a certain person—technically called the *drawer* or acceptor—shall pay to the drawee, the payee, or his representative, at a stated time, a stated amount in consideration of value received. Bills received from customers in *quasi* payment of goods are called Bills Receivable—that is, bills of which the money noted in them is to be received on maturity, or when they become due; and bills granted to parties from whom goods have been purchased are designated Bills Payable—*i.e.* bills which indicate that a sum of money is to be paid at a certain date. Bills may be variously expressed, but their tenor is in general somewhat as follows:—

LONDON, 23*rd Sept.*, 1888.

£352 10*s.*

Three months after date, *pay* to my Order, the sum of Three Hundred and Fifty-two Pounds Ten Shillings, for value received.

JAMES ANDREWS.

To MR. HOWARD BLACK,
33 LOMBARD ST., LONDON.

On such a bill being accepted—in which case it would bear across the face of it the word "accepted," together with the signature of Mr. Howard Black, and (usually) the place where payment is to be made—it may be entered in the Bill Book with all the particulars concerning it stated in the most concise and precise form, for example thus, in which the first form represents the entry in Mr. Andrews' Bill Book and the second in Mr. Black's:—

BILLS RECEIVABLE.

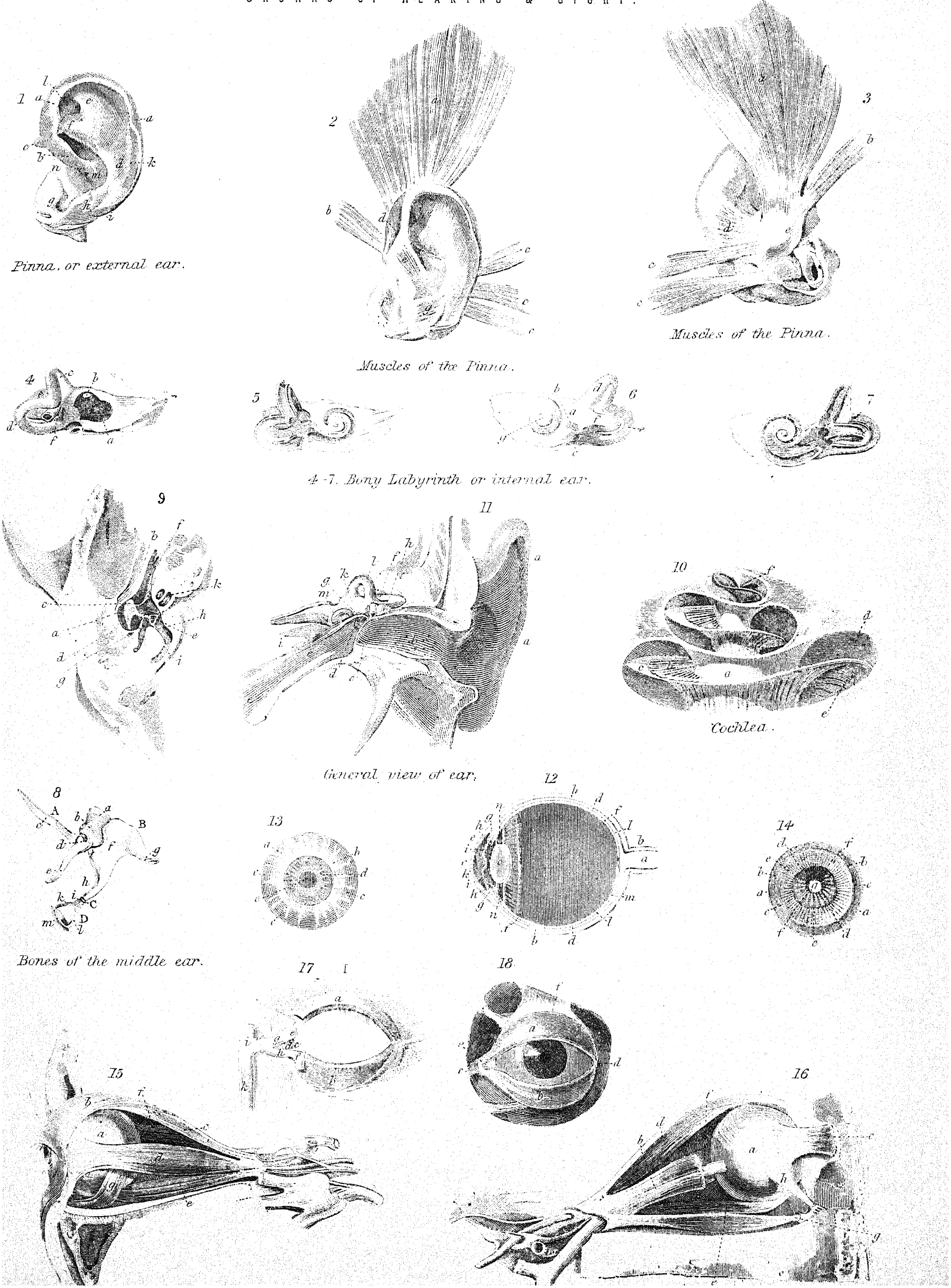
No.	Date [when Received.]	From whom Received.	The Sum [to be Paid.]	[Actual] Date [of Bill.]	Term [of Payment.]	When Due.	Cash Folio.	Ledger Folio.
17	24th Sept., 1888.	Howard Black.	£352 10*s.* 0*d.*	23rd Sept., 1888.	3 Mos.	26th Dec.	39	65

BILLS PAYABLE.

No.	Date [when Granted.]	To whom Granted.	The Sum.	Date.	Term.	When Due.	Cash Folio.	Ledger Folio.
31	23rd Sept.	James Andrews.	£352 10*s.* 0*d.*	23rd Sept.	3 Mos.	26th Dec.	48	33

PHYSIOLOGY.

ORGANS OF HEARING & SIGHT.



Pinna, or external ear.

Muscles of the Pinna.

Muscles of the Pinna.

4-7. Bony Labyrinth or internal ear.

Cochlea.

General view of ear.

Bones of the middle ear.

In some cases a column is added with some such heading as "How disposed of"—in which such entries are made as paid, renewed, dishonoured, protested, recovered, received dividend of (so much) per £, &c., as the case may be.

Bills are, in point of fact, a conventional currency, at least ostensibly, representing money. Given and accepted as cash for convenience' sake, they are not, however, treated precisely as cash; but a mode of recognizing and registering them has been devised in the Bill Book, so as to fulfil the requirements of trade. The Bill Book is really a supplement to the Cash Book, in which we register all moneys *promised* but not *paid*. Those which we have received, and for which we require to receive payment, being put among Bills Receivable, because we have and hold them in lieu of cash [to be] received; and those which we have granted, and of which we require to make payment, being put among Bills Payable, because we are holden, and ought to hold ourselves, bound to replace them by cash. Bills Receivable are therefore, as it were, *Dr.*, and Bills Payable *Cr.*—that is, hold the same relative place in the Bill Book that they would have had if they had been (not representative, but real) cash.

Bill Books are sometimes arranged with Bills Receivable on the left-hand side, and Bills Payable on the right; but more frequently one part of the book is arranged for the former and another part for the latter. Of course, if we want to know how we stand relatively as to "Bills due by us" and "Bills due to us," we must sum up the amounts of all bills receivable and all bills payable, and subtracting the less sum from the greater, the remainder will show the balance, and on which side it lies.

Bills are entered in the Cash Book when cashed—whether on being discounted before or on being paid at maturity—as cash received or paid, as the case may be, that is, if *received*, enter it in the Cash Book as Dr. Bills Receivable (giving the No.), and Cr. the account of the person from whom it has been received with it as a payment; and, if *granted*, make the person who received it Dr., and make a Cr. entry in your favour in Cash Book Bills Payable (adding the No.) Of course, all bills receivable are accepted in lieu of cash, and are as cash Dr., and all bills payable are granted in lieu of cash, and are therefore Cr., according to the general rule, holding good in regard to every account opened, that, so far as refers to the particular matter noted in any account, what is received is Dr., what is given out Cr.

The Invoice Book is a sort of subsidiary to the Waste Book. It is used for keeping an account of *goods bought on credit*. With every delivery of goods purchased an *invoice*, *i.e.* a priced list of the goods purchased (and sent), ought to be forwarded. It should state the quantity, quality, distinguishing marks or numbers (if any), price (gross and net), charges, commission, and any other important particulars requiring mention. The use of an invoice is to furnish a complete, correct, and ready record of all the particulars involved in the purchase. This when received should be, of course, not only carefully compared with the order given, but with the goods sent, to see that all these tally; but it ought also to be safely preserved, as an authorized statement of the purchases effected and their cost, &c. In the Invoice Book correct copies of these documents are made, and the sum of their amount is filled into an outer money column, so as to be readily seen at a glance. After the copy has been made, giving, of course, in legible characters the name and address of the persons from whom the goods have been bought, and extending the money-column as advised, the invoice should be diligently compared with the copy, and a memorandum should be made on the lower corner at the left hand—preferably in *red* ink, of the date of comparison of goods and invoice, and of the copy being taken—stating the page of the Invoice Book on which the entry has been made, and a mark V should be inserted in the margin of the book to show that this has been seen to. Thereafter each invoice ought to be taken, folded carefully (making, if possible, all invoices of uniform size when folded, and labelled with the name, date, and amount on the outside). They should then be arranged—either alphabetically or according to date—between two pieces of cardboard, put on a file, inserted in a slip book made for the purpose, or pasted into a rough cartridge-paper album, having index-letters, so as to be easily—even instantly—got if requiring to be referred to. Some houses only enter the names, address, dates, kind of goods, and total amount in their Invoice Book, and regard it as more convenient to preserve the invoices as sent, arranged in some readily inspected form, having had due care taken to *visé*, examine, and endorse entry and invoice in a proper way. It will at once be seen that the Invoice Book is really an expedient adopted to relieve the Waste Book from an accumulation of petty details only tending to increase its bulk and decrease its usefulness, at the same time that it relieves the Waste Book clerk from mere copying work, which can be attended to by a junior clerk. The Waste Book entry can then be restricted to a single-lined insertion running in this fashion:—

May 12th, 1888.

Messrs. Hamilton, Edwards, & Payne, Paragon Square, Derby.

	£	s.	d.
Bought Goods of (as per Invoice *p.* 31 B), . .	404	17	11

While the Invoice Book entry, if made in a book, might stand in full thus:—

Messrs. Hamilton, Edwards, & Payne, Paragon Square, Derby.
Cr.

	£	s.	d.	£	s.	d.
By 160 yards Black Silk, at 5*s.* 4*d.*,	42	13	4			
" 120 " Velvet, at 12*s.* 6*d.*, .	75	0	0			
" 150 " Coloured Silk, at 8*s.* 4*d.*,	62	10	0			
" 16 pieces Velvet, 20 yards, at 14*s.*, ...	224	0	0			
Wrapper, Package, Booking, &c.,	0	14	7			
				404	17	11

The Journal is an invaluable book, although considerable ingenuity has been exercised in inventing plans for dispensing with its use. It is, in fact, the digest of all the other entries made in the books already mentioned. It reduces each entry to its proper head, arranges and classifies every transaction according to the plan of ledgering adopted in the business, so as to fit it for immediate transference into the ledger, and it adjusts every item of the debit and credit transactions of the merchant or business man into its precise relation to the merchant and his customers. The principle on which it is constructed is exceedingly simple in its ideal, and though it is appropriated to use in double entry, it can be quite easily understood, even by the uninitiated, if they will attend to the very simple explanation required to show its use. Every transaction in business is of the nature of an exchange, that is, giving one thing on condition of receiving another as (in this sense) its equivalent. Every person who sells gives out of his stock what somebody else adds to his stock, and every one who pays for what he buys gives out exactly what the seller receives. Each person therefore, in his books, appears as a receiver, that is, a debtor for what he buys; and as an expender, and therefore a creditor, for what he pays. It is easily seen that in the account of any two merchants the records of their mutual transactions should be, in reality, exactly the same in their items, but that the Dr. side in the one's books will correspond with the Cr. of the other's, and *vice versa*. In book-keeping by double entry this ideal is realized by the duplication of the accounts in it; and the arrangement of those accounts so that between any two accounts there must necessarily be a *debit* entry made in each one, and a *per contra* to the *credit* one made in the other, so that the total of the credit entries must exactly balance the total of the debit entries, and *vice versa*. In the Journal the exact nature of the entries to be made in the Ledger are classified, arranged, noted, and prepared for transference. The Journal is thus arranged:—(1) On the left-hand side a column for the month; (2) for the day thereof; and (3) for the folio in the Ledger into which the entry has been posted (to be noted in the Journal after the entry has been made in the Ledger). In the centre of the page the title of the accounts in the Ledger to which the entries are to be transferred next appear, with an indication

of their being debit or credit. On the right-hand side are arranged double money columns, the inner reserved for Dr. entries and the outer for Cr. ones. Of course it will be seen that if each debit account is precisely balanced by a credit one (or more than one, making up an equivalent to one), each column on each page on being summed up should yield a similar total, so that the one column acts, in a certain sense, as a check on the other. The principle kept in view in this, as indeed in all book-keeping, is that everything that *comes in* to a business results in a Dr. entry, and everything that *goes out* forms a Cr. one. This being the case, let us see what shape the following simple (illustrative) transaction would take in journalizing. John Thornton, of Blythe Street, Liverpool, has supplied the firm, whose books it may be supposed we are keeping, with four hogsheads of sugar at £11 7*s.* 6*d.*, and six tons of tea at £4 4*s.*, and that due entries have been made of this transaction in the Day Book. We know that sugar and tea (having accounts assigned to them) have received the purchases, and that John Thornton has parted with them. These facts would stand thus under the journalist's classification:—

JOURNAL.

Month, Date.	Folio.	Accounts.	Dr. £	Dr. s.	Dr. d.	Cr. £	Cr. s.	Cr. d.
Nov. 18	41	John Thornton, Cr.,				70	14	0
	16	To Sugar, ...	45	10	0			
	8	" Tea.	25	4	0			
			70	14	0	70	14	0

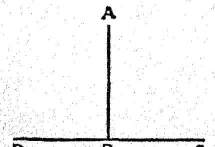
GEOMETRY.—CHAPTER V.

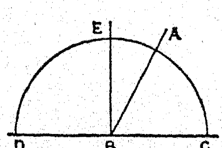
The magnitude of an angle is quite independent of the length of the lines by the union of which it is formed. The clearest practical idea of an angle that can be got is to be had by supposing one side of it to be superimposed upon the other, and thereafter to be turned about the meeting point, as the leg of a pair of compasses opens from the hinge, or as the blade of a knife opens from its joint. The *seventh definition* (p. 55) requires us to conceive of a right angle as precisely one-half of the possible angular space on one side of a straight line, and implies that the angles formed at any point of one straight line by the meeting of another with it, are equal to two right angles. The thirteenth proposition is an extension and development of that definition, and the fourteenth proposition is only the converse of the thirteenth one ; while the fifteenth, which might readily be deduced from definition 6, is really a development and rigorous proof of the accuracy of that definition. We have now to consider

Proposition XIII.

The angles which one straight line makes with another upon one side of it, are (1) *either two right angles, or* (2) *are together equal to two right angles.*

A very simple practical proof of this proposition presents itself at once, viz. :—Let A B be a straight line making angles with the straight line D C, on one side of it. Then with the meeting point B as centre, with any radius, let the semicircle D E C be described. It is obvious that the angles formed by





A B with C D are either two right angles, in which case (1) A B would be a perpendicular and D B A equal to A B C; or (2) a perpendicular, B E, being drawn, the angle E B D will be a right angle, and the angle E B C, containing the angles A B E, A B C, is another right angle, so that the three last-named angles are together equal to two right angles.

Euclid, however, proceeds very deliberately. He sees that there are evidently two possible cases before the mind—viz. (1) when the two (supposed or given) angles are equal to one another, and (2) when they are unequal. In the first case the proof is immediate, for by definition 7 each is a right angle, and all right angles are equal. [We must, however, beware of supposing that the converse is also true—viz. that all equal angles are right angles, which is very evidently an incorrect proposition.] In the second case, if A B D is the greater, a perpendicular, B E, drawn (Prop. 12) from the point B will fall within the angle A B D and divide it into two angles, E B D and A B E. Then the sum of the two angles E B D and E B C is equal to the sum of the three angles A B C, A B E, and E B D. But the angle E B D is a right angle, therefore the sum of the angles A B E, A B C, is equal to the right angle E B C, and the sum of A B D and A B C is equal to two right angles. Q.E.D.

Corollaries.—Two angles are said to be *supplementary* when their sum is equal to two right angles; and therefore, two angles whose supplements are equal, are themselves equal. If one be a right angle the other is a *right* angle; if one be obtuse the other is *acute;* and if one be acute the other is *obtuse.* A semicircle is the measure of two right angles, and all the angles formed by the converging of any number of straight lines to one point on another straight line, are together equal to two right angles. Two angles whose complements are equal are also equal one to the other.

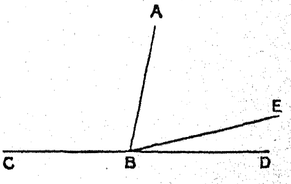
The preceding proposition is a *theorem* of great practical importance in trigonometry and astronomy; for when we know one of the angles which a straight line meeting another straight line makes at a point in it, we can easily find the other by subtracting the given angle from 180 degrees—*e.g.* let any angle equal 36 degrees, the other is 144; or let us take a right angle, which is 90 degrees, and we get one angle 36 degrees and the other 54 degrees. Any single angle of a triangle is less than two right angles.

The precise converse of the preceding proposition is now, by Euclid, placed before us, as a theorem, in

Proposition XIV.

If at a point in a straight line, two other straight lines on the opposite sides of it make the adjacent angles together equal to two right angles, these two straight lines shall be in one and the same straight line [or, if two adjacent angles are *supplementary*, their non-coincident sides are in the same straight line—*i.e.* must form perpendiculars to the coincident sides].

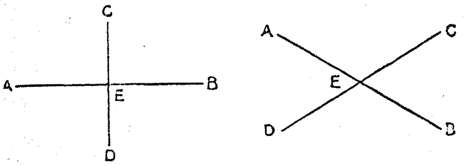
At the point B, in the straight line A B, let B C and B D make the angles A B C, A B D, together equal to two right angles, then B C and B D will form one and the same straight line. For the line C B produced must form with A B an angle equal to the supplement of A B C, that is, by hypothesis, equal to D B A, and hence B D must be the production (in the same straight line) of B C. If, however, this should not [seem to the student to] be the case,



let B E be made in the same straight line; then the straight line A B, with the straight line C B E, makes the angles A B C, A B E adjacent angles, which are together equal to two right angles (Proposition 13). But, according to the hypothesis with which we started, A B C and A B D are supplementary angles, and together equal to two right angles; and things which are equal to the same thing are equal to one another (Axiom 1). Therefore A B C, A B E are equal to A B C, A B D. Take away from these equal wholes the common part A B C, and the remainders are equal, that is, A B E to A B D, the less to the greater, which is impossible. The line B E is therefore not in the same straight line with B C; and it may be shown in a similar way—either by letting B E (1) fall below B D or (2) rise above it—that no other line than B D is in the same straight line. Wherefore, if at a point, &c. Q.E.D.

The theorem which Euclid next calls upon us to regard as true and right is really a development of the definition of an angle (p. 55). If the lines at the angular point are produced,

they must have the same inclination to one another as the original lines had, only in a different position. This appears very plainly in such angles as are given in the figure, where C E B and A E D are equal, because they have the same sup-

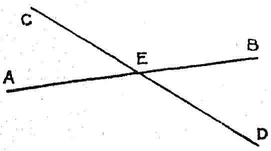


plement B E D; but it is not quite so perceptible in all cases, and Euclid proves it, broadly stated, to be a fact through the following illustrative figure in

Proposition XV.

If two straight lines cut one another, the vertical or opposite angles shall be equal.

We had, perhaps, better interject here the remark that angles are said to be *opposite* to each other when the sides of one are the sides of the other produced. Let the two straight lines, A B, C D, cut one another in the point E. The vertical angles, A E D, B E C, are equal one to another, and likewise A E C, B E D. The angles A E C, A E D are (1) adjacent angles, (2) together equal to two right angles. So likewise are the angles A E C, C E B. A E C, A E D are together equal to A E C, C E B therefore. From each of these equals take the angle common to both, A E C, and the remainders, A E D, C E B, are equal. In the same way it may be proved that A E C and B E D are equal.



The following very simple proof of this proposition has been suggested. As an angle is in reality only an opening between two straight lines occasioned or formed by the turning, to a greater or less extent, of one straight line round upon a fixed point in another straight line, if A B is made to revolve round the point E till the point A reaches and can be superimposed on C, then B will also have revolved till it can be superimposed on D, and therefore the angle A E C is equal to the angle B E D. Similarly the angle A E D equals B E C—that is, let the two straight lines which cut each other be regarded as fixed in space, and let one of them be imaginarily revolved round E as a centre, the precise amount of revolution required to bring the revolving line into exact superposition with the fixed one; and this would be equally true of each angle if revolved on the angular point as on a pivot. Q.E.D.

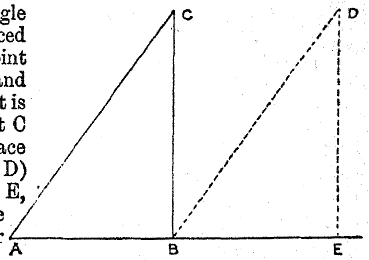
From this we derive the following corollaries, viz.—(1) If two straight lines intersect, *i.e.* cut each other, the angles which they make at the point of intersection are together equal to four right angles; (2) all the angles made by any number of lines meeting in one point are together equal to four right angles. Hence also, (3) When one of the four angles formed by two intersecting straight lines is a right angle, the three other angles are also right angles. (4) If, when a straight line is perpendicular to another straight line, the former line is produced, it will also be perpendicular to the latter straight line. (5) If a straight line is perpendicular to another straight line, the latter will also be perpendicular to the former (see figs. 1 and 2). Euclid does not prove the converse of Proposition XV., viz. "If the vertical angles made by four straight lines meeting in the same point be respectively equal to each other, each pair of opposite lines shall be in and form one and the same straight line."

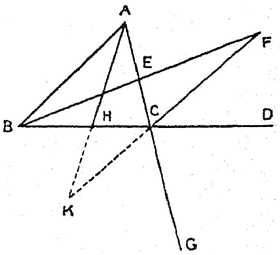
The thirty-second proposition of Euclid's first book is a most interesting and fruitful one. The sixteenth leads us somewhat on the way towards it. It might have been deduced as a corollary from Proposition 17, or the seventeenth might have been deduced as a corollary from it. Both are really included in Proposition 32, but Euclid prefers to make his progress sure if slow.

Proposition XVI.

If one side of a triangle be produced, the exterior angle (i.e. any angle formed by one side and another produced) is greater than either of the interior opposite angles.

An almost palpable proof of this proposition may be given in this fashion by superposition. Let A B C be the triangle, with A B, its side, produced. Slide that angle along on the produced side A B E, till the point A is placed on B, and the point B on E. It is evident that the point C must then take a place somewhere (say at D) within the angle C B E, and therefore the angle C B E must be greater than the angle D B E, or than its equal C A B. If the side C B is produced, the same reasoning will show that the angle C B E is greater than the angle at C. But the Euclidean demonstration proceeds with geometric orderliness, thus—Let A B C be a triangle, of which the side B C is produced to D. The exterior angle A C D is greater than either of the interior opposite angles C B A, B A C. According to Proposition 10, bisect A C in E, join B E, and produce the line by which that is done to F, making E F equal (I. 3) to B E. Then join F C. Because, by construction, A E is equal to E C and B E to E F, we have in the triangles A E B, C E F, two sides A B, E B, equal to the two sides C E, E F, each to each. But (I. 15) the angle A E B is equal to the angle C E F, because they are vertical angles. Therefore (I. 4) the base A B is equal to the base C F, the triangle A E B to C E F, and the remaining angles of the one equal to the remaining angles of the other, each to each; namely, those to which the equal sides are opposite. Hence the angle B A E is equal to E C F; but the angle E C D is greater than the angle E C F (Axiom 9), and therefore the angle A C D is greater than the angle B A E. By a similar process of reasoning, if the side A C is produced to G it may be shown that the external angle B C G is greater than C B A; but A C D is equal to B C G (I. 15), and hence A C D will also be greater than C B A is, and therefore greater than either of the interior remote angles. We indicate on the figure a solution of the last case, and strongly recommend the student to write out in full the demonstration of both cases, so that the accuracy of the proposition may be firmly impressed on his mind by the force of conviction. It may be advantageous here to note that Euclid's reference to Axiom 9 does not logically cover the whole inference upon which he insists. The axiom on which he founds requires to run thus:—If two things, A and B, are equal to one another, and one of them, A, be greater than a third, C, then the other, B, will also be greater than the third, C.





From this proposition we gain as corollaries—All the exterior angles of a triangle are together (1) greater than all the interior ones; (2) greater than three right angles; (3) if the exterior angle A C D is a right angle, the interior opposite angle is less than a right angle; and consequently, (4) there cannot be two straight lines, A C, A B, drawn from the point A perpendicular to the line B C—that is, from a point without a straight line only one perpendicular can be drawn to it; (5) a triangle cannot have more than one *right* angle, nor more than one *obtuse* one; (6) in a right-angled triangle the two acute angles are complementary; (7) any exterior angle of a triangle is equal to the sum of the two interior opposite angles.

BOTANY.—CHAPTER V.

FOLIAGE—LEAVES AND THEIR PARTS—STRUCTURE OF LEAVES —SIMPLE AND COMPOUND—VENATION—PHYLLOTAXIS—TABULAR VIEW OF LEAF-CHARACTERISTICS.

THE infinite variety which Nature is able to impart to objects having a similarity of purpose and form is scarcely in anything more strikingly exhibited than in the leaves of plants. They form a large part of the beauty of the world in their spring freshness, their summer fulness, and their autumnal glory of changing hue. In them grace and diversity of shade, elegant simplicity, and pleasing symmetry of shape, are most gratifyingly combined. Even the eye of an ordinary spectator is arrested by the many-shaped leaves which attract his attention. He sees in their margins great ingenuity and diversity of serrations. Their venation and reticulations excite surprise and wonder, and the arrangements of leaves upon the stem can scarcely fail, when observed, to suggest ideas of organization and classification. When they stir in the wind, twinkle in the morning sunshine, or seem to hang idly in the slumbrousness of a sultry noon, their surfaces show curious differences and characteristics, to which even custom cannot make us indifferent. Leaf-beauty is admitted and admired by all; and there are few minds which do not feel the charm of fresh foliage in woodland masses, by streamlet banks, or mountain brow, or in meadow-level, when

"Moist, bright, and green the landscape laughs around."

But botany gives even a finer seeing to the eye, and communicates to the meditative mind an intenser joy in observing the leaf-forms of the vegetable world. It brings into association the external appearances and the internal characteristics of plants, and enables us from the outer signs to infer the inner quality of nature. The landscape is made quick with thought; intellectual delight is added to sensitive pleasure; and we learn that leaves are not unfrequently, in various ways, interwoven with our welfare.

The leaf is, by morphologists, regarded theoretically as the type on which all the other organs which are found upon the stem are formed, and as affording to the mind an ideal point from which they may be said to have departed. A leaf generally consists of an expanded portion called the blade or limb, and a stalk or petiole, which latter sometimes expands at the base into a sheath or vagina embracing the stem, or becomes transformed into leaflets called stipules. Those springing from the root are called radical (Lat. *radix*, root) leaves; when they rise from the stem they take the name of cauline (*caulis*, stalk), and when supplied by the branches or flowers, they are termed respectively ramal (*ramus*, a bough) and floral (*flora*, relating to blooms). Leaves almost always expand horizontally, presenting one surface to the earth, and the other to the sky. This is their regular position, and corresponding with this, we commonly find a very marked difference, both in colour and texture, between the upper and under surfaces, which is appreciable by the naked eye. By aid of the microscope we find that the apparent difference originates in the intimate structure of the parts. The upper surface is usually composed of a single layer of oblong cells, very compactly arranged, with their ends presented to the expansion, so as to leave exposed the least possible extent of single walls and intercellular spaces. But in plants which inhabit dry and sterile regions these superficial cells often consist of two and sometimes three layers. This arrangement is evidently designed to check evaporation and to regulate the expenditure of the fluids. In the lower surface the cells are oval or ovate, and very loosely arranged, so as to admit of many intercellular spaces. But in leaves which admit of both surfaces being exposed equally to the light, there is no difference between them. In actual plant-life we know that bracts, involucres, and all the parts of flowers are really results of the metamorphoses of leaves. Different parts of the stem produce different kinds of leaves. Scale-leaves, or *phyllodes*, simple in outline and without venation, are developed at the lower part of the stem, and at the base of the shoots; *bracts*, or floral-leaves—the leafy appendages to the flower—belong to the upper portion of the stem, have their place close to the flower, are stalkless or sessile, with a narrow base, and generally of smaller size than the foliage, from which they also differ in colour and texture. Foliage-leaves are developed between the scale-leaves and the bracts, are exceedingly varied in form and appearance, and usually manifest the possession of large quantities of chlorophyll, *i.e.* leaf-green. The portion of the stem or branch from which a leaf springs is a *node*, the space between two nodes an internode. Leaves take origin close to the growing point of the stem, and proceed in acropetal order. Leaves are all crowded together at first, and form the buds. From the buds, under proper influences, they in due time burst and appear as foliage.

Leaves which, when they separate from the stem, leave a scar as a sign of their connection with and growth on it, are called articulated; and those which do not drop or fall off but decay gradually on the stem, non-articulated. Grasses and ferns are instances of the latter; almost all trees afford examples of the former. Leaves which fall off after having performed their specific function in one season, and without waiting till new ones are formed, are deciduous; those which last beyond the season, and wait till new leaves are formed, are persistent, like those of the cherry laurel.

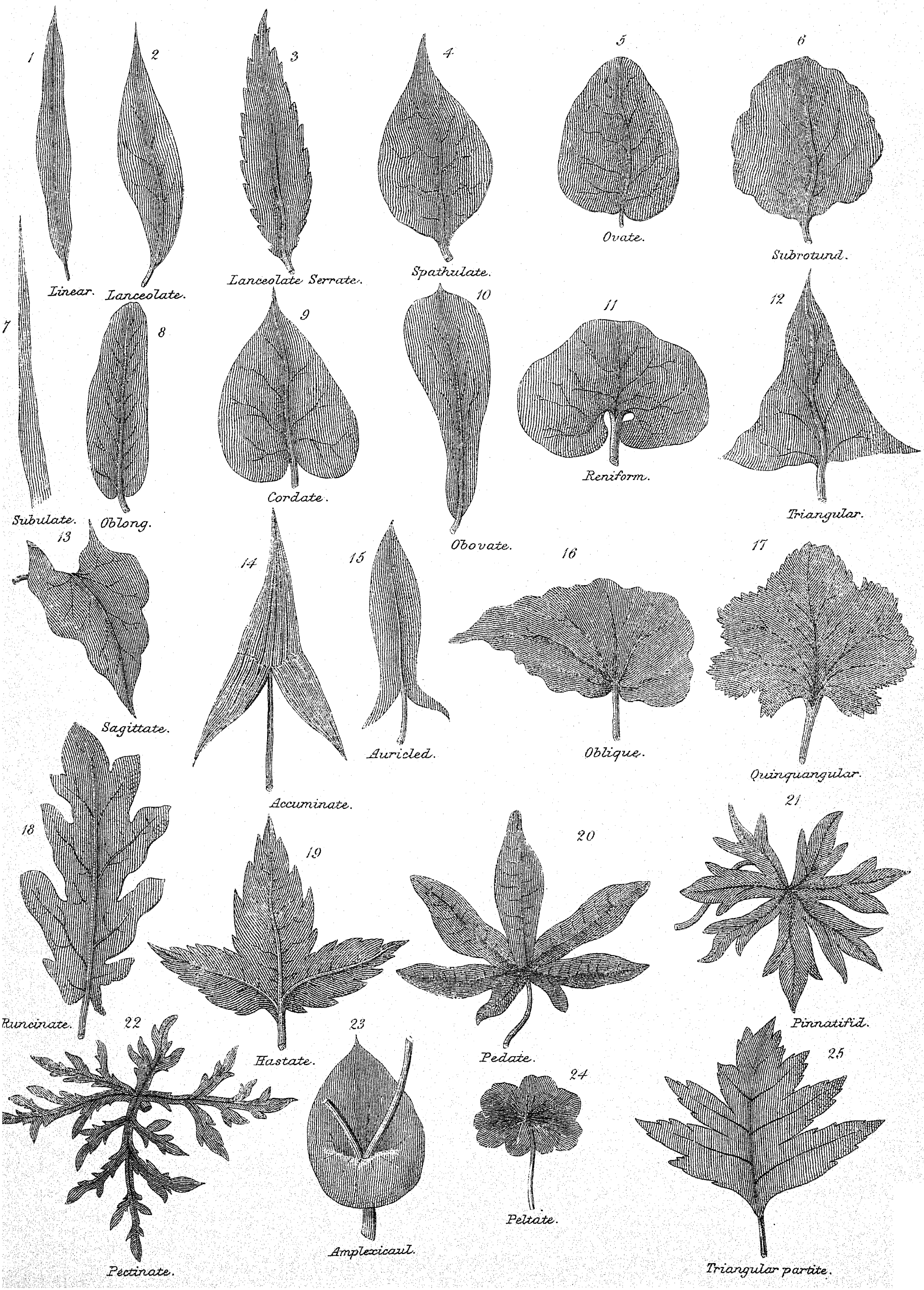
The nervous structure of leaves corresponds with the organization of seeds, and is indicative of the great divisions of the vegetable kingdom. In the netted races, woody tubes (sometimes but not invariably associated with dotted tubes) are arranged around a central pith, which radiates in medullary plates, reproducing itself on the *circumference*. In those which have parallel veins the trunk is formed of woody tubes interspersed as guards through spiral and dotted vessels, which are reproduced in the *centre* of the trunk. In acrogens or acotyledons the leaves vary with the structure, and are typical of the plan on which that has been formed.

As regards structure leaves are arranged into two classes—(1) *aerial*, those which grow entirely or partially in the free air; and (2) *submerged*, those which grow under water. Aerial leaves, except those of the simplest sort, like those of the mosses, which consist merely of cellular tissue, exhibit both a cellular and a fibro-vascular system. The soft parts of the blade are cellular, the hard parts—the ramifications of the venation—are fibro-vascular. An epidermis—*i.e.* a thin transparent pellicle—or skin, consisting of tubular or flattened cells, invests the whole surface, upper and under. This is furnished with stomata, orifices or minute openings, varying in number, arrangement, and form in different plants, but most abundant on the under surface. These stomata are the organs of exhalation. They are situated so as to open directly into the air-chambers of the intercellular system by which they are surrounded, and through them a circulation is kept up between the cells of the interior of the leaf and the outer air. These are the lungs or the breathing apparatus of the plants. They are constructed on the principle of a self-acting valve, and are extremely sensitive to the influence of moisture. When there is an excess of water in the system they elongate themselves, curving outwardly, and thus open a passage for the exhalation of the superfluous water; but when there is a deficiency of water, and they become dry, they shorten and straighten themselves, so as effectually to close the passages, and thus prevent exhalation. Thus the very moment that there is a want of water in the system the door is closed against its useless expenditure. These organs are generally too delicate to bear the fierce power of the sun, and hence are chiefly found upon the lower surface of the leaf, where they are so numerous that 120,000 have been counted upon a square inch of surface. In leaves of which both sides are exposed to the light alike, the stomata are equally distributed over the surfaces; in leaves which float in water, the stomata are all on the upper surface; and in completely submerged leaves they are not found; neither are there any found in the roots of plants. What may be called the epidermic appendages are of various sorts, such as (1) non-secreting organs, *e.g.* hairs—filiform or threadlike prolongations of tissue; scales or scurf, membranous bodies somewhat like chaff; and bristles (stiff processes) and prickles; (2) secreting organs, as glands, little transparent dots of a somewhat hairy-like nature, containing the characteristic oils, resins, &c., which distinguish plants; and stings, a sort of knob-

BOTANY.

PLATE V.

SIMPLE LEAVES



pointed hairy form, enlarged at its base, and containing there a pouch in which some irritating secretion is elaborated, which, on the plant being touched, passes up the capillary cavity, and is projected on or into the touching part. Submerged leaves are wholly made up of cellular tissue, have no epidermic stomata, have often considerable intercellular spaces and frequently large air-cavities, characteristics which not only give them a thickened appearance, but also diminish their weight, and enable them the more readily to be held in suspense in the water.

Foliage-leaves are, in general, more or less flattened expansions of the *parenchyma*—*i.e.* cellular tissue of the stem. The different stem-tissues, epidermal and fibro-vascular, are continued into the leaf. Leaves are divided into two similar halves by a midrib running along between them from base to apex. The angle formed by the junction of the upper surface of a leaf with the stem is called the *axil;* the part of the leaf nearest the axis is designated the *base*; the further extremity, the *apex;* and the lines which run along on the outside edge between apex and base, the *margin.* Sometimes on each side of each leaf, as in the rose tribe, those small, delicate, leaf-like organs called *stipules* are found. The petiole is usually round (or nearly so). In grasses, however, and other similar plants it is rolled round the stem and bears the name of a *vagina* or sheath. At the upper end of the sheath of such plants there often occurs a thin membrane called a *ligula.* Though the blade be usually a flat, expanded, symmetrically contextured form, yet it may be unsymmetrical (as in the begonias), thick, fleshy, and succulent (as in stone-crop), or of a brown scaly appearance (as in the broomrape). Occasionally stipules form an *ochrea*, that is, a membranous tube surrounding the stem and looking like a holder, or containing protection. In various other ways leaves may be peculiar—elongated, cylindrical, prism-like, tubular, &c. Indeed, the characteristics of leaves, in form, texture, colour, smell, surface, quality, are far too numerous to be detailed in any brief popular outline, and almost too minutely varied to be capable of description in any other than a most intricate and peculiar technical language. On this account we prefer placing before the eyes of our readers a large, carefully selected, and distinctly reproduced series of illustrations of leaves, so plainly appealing to the eye that only a word or two of discriminating technical terms may suffice to identify them and secure their being known by an attentive observer of Plate and plant. Commending the diligent comparison of letterpress and picture wherever a reference is made in the former to the latter, we proceed to treat of the leaf as a botanical element—one of the most widely-known and easily discriminated of what are now called "the appendicular organs" of plants.

Leaves are said to be (1) simple and undivided, (2) simple but divided, and (3) compound. Nature has utilized every possible variety of form in leaf outlines. When the blade of the leaf is in one piece the leaf itself is *simple;* but a simple leaf may either be undivided—*i.e.* all in one piece, as in the elm—or divided into several parts, though each division is attached by a broad base to the midrib, as in the oak, the turnip, or the mountain fern. When the leaf is formed of two or more entirely distinct and separate portions, each attached to the petiole in the same manner as the petiole is attached to the stem, it is termed *compound;* its disparate portions are *leaflets*, the main axis is the *common petiole*, and the leaflet stalks *partial petioles.* However numerous or minute the divisions or subdivisions of a hemlock leaf, for instance, may be, the parts are all truly conjoined to, and interwoven with, the other portions, and not the smallest of them can be detached from the others without tearing them; but in compound leaves, like those of the horse-chestnut, the various leaflets are articulated to the petiole, and any one may drop off without injury to any other. Simple undivided leaves may be—(1) needle-shaped, as in the pine and fir; (2) linear, long and narrow, with margins either parallel or tapering to a point, like grass; (3) lanceolate (spear-shaped), long and narrow, but tapering towards each end; (4) lingulate (tongue-shaped), with margins parallel, but ends rounded; (5) oval, twice as long as broad, narrowing towards each end; (6) ovate (egg-shaped), oval, but narrowing most towards the apex or upper end, and obovate (inversely egg-shaped) when the narrowing is towards the base; (7) circular or elliptical, more or less nearly round; (8) reniform (kidney-shaped), as in *Asarum Europæum;* (9) cordate (heart-shaped), as in the convolvulus; (10) triangular (three-cornered); (11) hastate (spear-head-shaped); (12) oblique, as in the Begonia; (13) sagitate, arrowhead-shaped, as in the *Sagittaria sagittifolia;* (14) spathulate, resembling a spoon.

Simple but divided leaves cannot be very sharply discriminated. There is a difficulty in determining precisely where the line may be drawn between them. A divided leaf really means one in which the spaces between the veins are imperfectly filled up, so that intervals are found between the parts. Simple but divided leaves may be arranged into two classes: (1) feather-veined, *i.e.* those in which the leading vein proceeds direct from petiole to apex; (2) fan-veined, *i.e.* those in which the leading veins branch out from the petiole like the divisions of a fan. Of the former sort, the most important are—(1) pinnatifid, divided in feather fashion, also pinnatipartite or pinnatisected, according to the depth of the cleaving or fissure; (2) lyrate (lyre-shaped), when the terminal lobe is large and rounded, and the lateral lobes become smaller towards the base; they may be doubly or triply pinnatifid, when the segments are themselves also cut or cleft; (3) runcinate, when the terminal lobe is large, the segments pointed and directed towards the base; (4) pectinate (comb-like), when the segments are narrow, close, and parallel, like the teeth of a comb. Of the latter sort the more special are (1) fan-lobed, having five or more large clefts directed towards the leaf-stalk; (2) fan-lobed and cut, as in the monkshood; (3) palmate (like the palm of the hand), when the fissures extend to nearly the base of the leaf, as in many passion-flowers; ternate, united in three leaves, as in the wood-anemone and the strawberry. Other forms are bilobate, two-lobed; trilobate, three-lobed; hastate, halberd-shaped; palmate, five-lobed; pedate, resembling a foot.

Compound leaves are distinguished by having each of their leaflets individually *articulated* by a ramification of the petiole to the common petiole. They are *pinnate* or feather-formed, or *palmate;* the former when the leaflets are arranged along the sides of a common petiole, the latter when they radiate from a common point. When the leaf ends in a pair of leaflets, it is said to be abruptly *pari-* (or equally) *pinnate;* when it ends in an odd leaflet it is *impari-* (or unequally) *pinnate;* when the leaflets are alternately large and small, it is *interruptedly pinnate;* and when their terminal leaflet is the largest, and the others decrease in size towards the base, they are styled *lyrately pinnate*, as the leaflets of a pinnate leaf are named *pinnæ.* When the petioles of the leaflets also have leaflets along their sides those leaflets are called *pinnules*, and the whole leaf is designated bipinnate. If the pinnules are pinnate, the leaf is tripinnate. Palmate or fan-typed leaves are (1) quinate when five leaflets proceed all from the same point; (2) septate when there are seven; and (3) digitate when the leaflets are numerous and narrow, resembling fingers.

The next noticeable feature in leaves is their margin. They are said to be (1) *entire* when perfectly unbroken; (2) *serrate* when toothed like a saw, and *doubly-serrate* when the dentations are also toothed; (3) *crenate* when the indentations are rounded; (4) *ciliated* when set round, like the new-opened foliage of the beech, with fine eyelash-like hairs; (5) *prickly* when the angles of the leaflets are expanded into sharp points like the holly-leaf; (6) *sinuate* or waved when the edge resembles the concave curves and angular ridges of drawings of sea-surfaces.

The part of the leaf furthest from the stem is called the *apex.* It may be (1) pointed, when it curves regularly up to a peak. When the point is fine it is *acute*, and when elongated into a gradually lessening point, it bears the designation of *acuminate;* (2) obtuse, when rounded off or blunt; abrupt, when the end seems nipt off: and truncated, when it appears to be cut off square; (3) macronate, when tipped abruptly with a short, sharp, spiky point; (4) retuse, when the blade terminates in a broad shallow notch; (5) emarginate, when the notch is sharply defined and triangular in form.

Venation.—The manner in which the veins are distributed

in the leaf is termed venation. This varies in different plants. In thick or succulent leaves veins cannot be distinguished on account of the mass of cellular tissue in which they are embedded. In the lower order of plants, such as lichens and seaweeds, and in submerged leaves, they are absent altogether. The shape of the leaf in configuration and profile, the characteristics of the margin, the apex, and the base, are of course, in a great measure, determined by the peculiarities of their veinings. In an ordinary leaf, as in that of the oak, there is a central continuation of the petiole or footstalk, which is larger than the other veins. This is called the midrib; it then gives off other veins from either side, which are called primary, and if these give rise again to others they are called secondary, &c., or the midrib is termed the mid vein, then the veins, veinlets, and veinulets. Leaves of this kind, with one large rib, are called unicostate (Lat. *unus*, one; *costa*, rib). In leaves such as those of the sycamore, in place of one central rib there are two or more diverging from the point of the junction of the blade with the petiole. These are called multicostate (many-ribbed). In all these instances there is a complete network of veins produced, hence the term reticulated venation has been applied (Lat. *reticulum*, a net). In some instances the veins end in curvatures within the margin of the leaf; when they take this form, for the sake of distinction they have been termed feather-veined. In plants of a certain kind, of which grass may be taken as an example, there is a midrib and vein running parallel to it from the base to the apex of the leaf, or in some other less familiar instances there exists a central midrib, with veins running from it to the margin of the leaf in a straight, or nearly straight, direction, as in the plantain or banana of the tropics. In both cases there are generally small veinlets uniting the veins together, but they do not form a regular network, and are insufficient to prevent the leaves from being torn down in strips between every pair of veins. These are instances of parallel-veined leaves. In the leaves of ferns a third kind of venation is distinguishable, in which the vein divides in a forked manner. This is termed furcate (Lat. *furca*, a fork). As a general rule, exogenous plants are possessed of leaves with a reticulated or netted venation, endogenous plants of leaves with a parallel venation, and acrogens of furcate-veined leaves. When the blade of a leaf is held up between the eye and the light, we see it traversed by fibro-vascular bundles varying much in number and direction. Sometimes they are imbedded in the substance of the leaf, sometimes they form a beautiful reticulation (or network) on the under side, and mark with beautiful lines the smooth and glowing sheen of the upper surface. What is technically called "skeletonizing leaves" by macerating them so as to induce the decay of the cellular substance and to retain only the delicately-veined fibres for mounting under a glass shade, has become fashionable of late, and hence people have got hold of a good idea of the venation of leaves. Venation is of great importance as regards the outline of the leaf; but as the venation of leaves nearly invariably corresponds with the structure of the stem and the nature of the flower, it is for the most part quite different in monocotyledons and dicotyledons, and supplies one of the three great leading characteristics by which botanists determine the primary divisions of the vegetable realm.

In venation, leaves are reticulated or net-veined, in which the veins and veinlets interlace and variegate the surface in every direction. In some of these, which are of the vertebrate type, a large, thick trunk vein, the midrib, proceeds straight from the petiole to the apex, and divides the blade into two equal parts. From this the lateral veins pass off in parallel lines (as in the chestnut) to the margin. This is pinnate venation. If the veins go from the midrib in a wavy, wandering course, the venation is called wandering or deliquescent. In others, the midrib has two or more large fibres nearly equal in bulk and strength to itself, side by side with it. The venation of these is called ribbed—of which the ribwort and the cinnamon afford examples. In yet a third variety, the venation is (1) fan-like and palmate, the main fibres being straight and widely-divergent; (2) curvilinear or converging, in which, as a general rule, slender fibres proceed from the base, run side by side, without interlacing, and converge gradually, as in the lily of the valley, towards the apex. When the lines are truly convergent, the veinlets do not reticulate, but cross over from one to another nearly at right angles to the main branchings, like the Madagascar Ouvirandra or lattice-leaf plant. In many tropical plants—as in ginger, arrow-root, and banana—the side-veins pass off from the midrib on either hand and curve gracefully into the margin—three-forked—in which the veins take the appearance of an oft-repeated letter Y—as in the old-fashioned Salisburia. The first species of venation belongs in the main to dicotyledons, the second to monocotyledons, and the third to acotyledons, and hence form an outwardly manifest general means of classification.

We had better now notice, in a few words, the leaf-base, that is, the part of the blade nearest the stem. Some leaves embrace and sheathe the stem, and are hence named amplexicaul, of which parsley supplies an instance; others are perfoliate, *i.e.* by the union of their margins so inclose the stem that it appears to pass through them, as those of the common hare's-ear do; another sort still, growing together on opposite sides of the stem, unite by their bases (as the common yellowwort and some honeysuckles do), are designated connate; if, again, the base of the leaf is so prolonged as to form an appendage to the stem, as is the case in thistles, the technical name for it is decurrent.

Phyllotaxis, or leaf-arrangement, is a most important department of botany—a study which, above most others, cultures observativeness and trains to precise definition. The way in which leaves are disposed upon the stem often enables a skilled botanist to determine to which family a plant belongs. If leaves do not grow upon the same level of the stem, but are set singly on, one a little above or below the other, as in a branch of beech or whitethorn, they are denominated alternate; but if they grow in pairs, as in a spray of lilac, exactly on the same level and facing each other, they are said to be opposite. If more than two leaves, as is the case in goose-grass, are antiposed to each other—*i.e.* set in a star-like fashion—they are verticillate or whorled. Whorls may consist of three or four leaves, and may possess as many as nine, as in the mare's-tail. In the common yellow loose-strife and the purple lythrum all these conditions of leaf are found.

The doctrine of *phyllotaxy* is, that leaves are normally alternate, that on account of failure in the development of half of their internodes—*i.e.* the length of stem between leaf and leaf—they become opposite, and by the non-development of several internodes they become verticillate. Myrtles sometimes show this interchange from alternate to opposite, and fuchsias frequently exhibit the change from opposite to verticillate. The ordinary normal leaf-whorl or spiral runs as a rule thus—1, 2, 3, 5, 8, 13, &c. Exceptional systems of verticillation run thus—1, 3, 4, 7, 11, &c., or 1, 4, 5, 9, 14. Morphologists explain any variations from the theoretical types by the increase, decrease, or adhesion of the normal leaf-organs, *i.e.* parts. It is to be understood, however, that though the arrangement of the leaves differs in different kinds of plants, it remains regular in the normal plants of each different sort. After reaching their full development leaves retain their form and size until they wither, fall, and die.

A few plants are leafless, such as the cactus tribe (except pereskia), and many of the parasitic plants, *e.g.* the common dodder. Some parasites, like the toothwort, have only scale-leaves, which are white and succulent. In leafless plants the functions of nutrition and respiration are performed by the green juicy rind of the stalk, or, in the case of the acrogens, by the outspread surface of the thallus. In these more or less modified stems an extensive green epidermal surface is produced, to afford compensation or provide substitute agency for weak leaf-development. The phylloid leaf-like shoots of asparagus and the green thorny spines of the furze act as compensatory substitutes in leaf-function. Other special modifications of leaves occur. The whole or part of the leaf of leguminous plants becomes a tendril. Leaf-spines appear in the barberry. In the pitcher-plants, Nepenthes and Sarracenia, the leaf is modified into a digestive organ—in the former for the absorption of animal matter, and in the latter for the appropriation as food of putrescent matter. In the Australian acacia flattened petioles (*phyllodes*) are often

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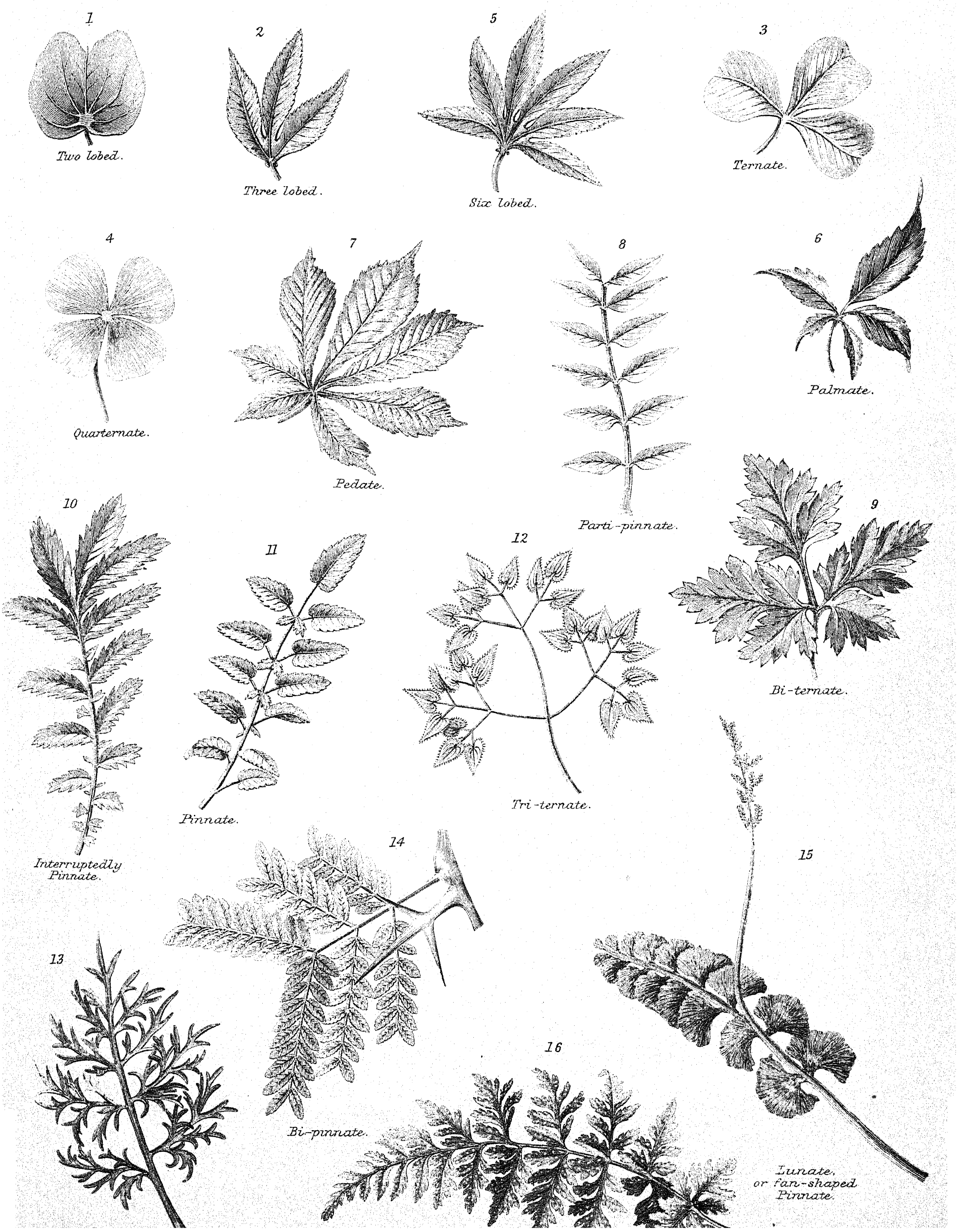
PLATE VI.

COMPOUND LEAVES



found taking the place of compound leaves. Phyllodes may be, in most instances, distinguished from true leaf-laminæ (1) by their surfaces being on both sides precisely alike, and (2) by their margins instead of their surfaces being held skyward.

The following tabular view of the various characteristics of leaves will not only supply a complete *vidimus* of this chapter, but will also enable the student to compare it with Plates V. and VI., which give various typical forms of simple and compound leaves:—

SUMMARY OF THE CHARACTERISTICS OF FOLIAGE.

LEAVES.

A. *Duration*—(1) Deciduous; (2) persistent.

B. *Leaf-arrangement*—(1) Alternate; (2) opposite; (3) verticillate; (4) scattered.

C. *Tissue*—(1) Vascular, giving venation; and (2) cellular, giving substance.

D. *Parts*—(1) Petiole; (2) blade; (3) veins.

E. *Function*—(1) Elaboration or nutrition; (2) respiration or aëration.

F. *Surface*—(1) Epidermis: (*a*) smooth, (*b*) glabrous; (2) stomata or transpiratory pores; (3) chlorophyll granules.

G. *Form*—(1) Simple and undivided; (2) simple but divided; (3) compound.

Simple and Undivided Leaves.

(1) Needle-shaped; (2) linear; (3) lanceolate; (4) lingulate; (5) oval, ovate, or obovate; (6) circular; (7) reniform; (8) cordate; (9) triangular; (10) hastate; (11) oblique; (12) peltate (shield-shaped).

Simple but Divided.

I. Feather-lobed or (1) pinnatifid; (2) pinnati-partite; (3) pinnati-sect; (4) pinnati-lobate. They may also be lyrate, runcinate, pectinate, &c.

II. Fan-lobed or (1) palmifid; (2) palmi-partite; (3) palmi-sect; (4) palmi-lobate. They may also be ternate, bi-ternate, palmate, pedate, &c.

Compound Leaves.

I. Pinnate: (1) binate; (2) trifoliate; (3) pari-pinnate; (4) impari-pinnate.

II. Palmate or radiate: (1) quintate; (2) septate; (3) digitate.

H. *Insertion*—(1) Petiolar; (2) sessile; (3) vaginal; (4) stipulate; (5) exstipulate.

STIPULES.

I. Lateral } (1) free; (2) adnate; (3) adnate-perfoliate;
II. Axillary } (4) connate.
III. Anti-foliar.

I. *External outline*—(1) Emargination; (2) base; (3) apex.

I. Margins are (1) entire; (2) serrate; (3) prickly; (4) lobed: (5) pinnatifid; (6) multifid; (7) ciliated; (8) crenate.

II. Bases are (1) amplexicaul; (2) perfoliate; (3) connate; (4) dilate, and are either (*a*) entire, or (*b*) split; (5) imbricate; (6) decurrent.

III. The apex is (1) acute: (*a*) pointed, (*b*) acuminate; (2) obtuse: (*a*) abrupt, (*b*) truncated; (*c*) mucronate

J. *Origin*—(1) Radical, springing from the root; (2) cauline, springing from the stem.

K. *Venation*—(1) Reticulated (exogenous); (2) curvilinear (endogenous); (3) forked (acrogenous): (*a*) simply, (*b*) compositely.

For an explanation of the terms used in the above table, the student is recommended to turn to the definition given in the preceding chapter, and then to refer to Plates V. and VI.

THE GERMAN LANGUAGE.—CHAPTER VII.

THE VERB.

An exact knowledge of the use of the verb is essential to the thorough mastery of a language. In most languages the inflexions of the verb are numerous and difficult. The German conjugations are, however, formed on principles so much akin to the English method that, in the modern manner of studying them, they are considerably easier to understand and retain in the memory than those of several other living languages. The inflexions which constitute the conjugations of German verbs occur in the present and imperfect tenses of the active voice, the imperative mood, and the participles, present and past. These parts, together with the infinitive, form and supply the groundwork of the conjugation of every German verb. All the rest of the verb in the *active* voice, and the whole of the *passive* voice, is formed, as is the case in English, by a combination of participles or infinitives with conjugated tenses of some of the auxiliary verbs of tense or mood. The German verb has the same number of simple tenses as the English, and the compound tenses are formed on precisely the same principle. There are only two conjugations, the one *weak*—corresponding to the English regular verb, and the other *strong*—answering to English irregular verbs. All those verbs which form their imperfect tenses by a change in their root-vowels are called *radical* verbs, and constitute the *old* or strong conjugation; all verbs which form their imperfect by inflexional terminations are called *derivative* verbs, and constitute the *modern* or weak conjugation.

German verbs do not differ materially in conjugation from English ones. There are the same moods and tenses in each; the tenses that are simple in English are simple in German; and for the formation of the other tenses similar auxiliary verbs are employed in both languages.

The principal parts of a verb in the active voice are—(1) the Infinitive Mood; (2) the Present Tense; (3) the Imperfect; and (4) the Past Participle.

If the verb be regularly formed, the derivation of these parts, one from another, is very simple. The infinitive mood always ends in en; as lieben, to love. From this the first person of the present tense is formed by dropping n; as ich liebe, I love; from this present the imperfect is formed by adding te; as ich lieb(e)te, the e being omitted if the word can be pronounced without it; and from this imperfect the participle is formed, by (1) dropping the final e, and (2) by putting the augment ge before it; as geliebt. From these four parts all the other tenses and moods are formed.

The tenses are as follows:—

1. *Present*, denoting an action or existence going on at the time in which one speaks.

2. *Past*—(1) Imperfect, denoting an action or existence which, although past, was part of a continual, repeated, or habitual line of action.

(2) Perfect, denoting an action or existence definitely past and completed, without relation to any individual period of time.

(3) Pluperfect, denoting a past action or existence, as related to another past action which it preceded or followed.

3. *Future*—(1) Absolute, denoting an action or existence in a period to come.

(2) Relative, denoting an action or existence which will be past before a future period which is still to come.

Each tense has two numbers—the singular and the plural. Each of these numbers has three persons, which are denoted by the pronouns ich, I, du, thou, er, he (sie, she, or es, it); wir, we, ihr, you, sie, they.

Verbs which admit of the use before them of the above personal pronouns are called *personal* verbs; those which are only joined with the impersonal pronouns es, it, or man, one, are called *impersonal;* as es regnet, it rains; man sagt, it is said; man findet, one finds.

Tenses are either *simple* or *compound.* The simple tenses are formed by changing the terminations alone, while the compound ones are formed by means of verbs, which for that reason are called *auxiliary.* The auxiliary verbs are divided

into two sets. The first consists of three verbs, which are called *the auxiliary* verbs; they can be used alone as well as in combination with other verbs, and are sein, to be, haben, to have, and werden, to become. In German they are used in very much the same way as they are in English.

The second set of auxiliaries are called the *auxiliary verbs of mood*, because they are never used alone, and are only employed to *modify* the meaning of other verbs, by expressing the willingness, possibility, necessity, or lawfulness of the thing or person spoken about.

In the three following verbs the student should first thoroughly master and learn by heart the present, imperfect, and future tenses of the Indicative, the present Conditional, and the Imperative, Infinitive, and Participles of each verb, and when he turns to the remaining tenses he will find them give him little trouble:—

AUXILIARY VERBS.

Sein, To Be. — Haben, To Have. — Werden, To Become.

Indicative Mood.

PRESENT TENSE.

	Sein	To Be	Haben	To Have	Werden	To Become
S. 1.	Ich bin,	I am.	Ich habe,	I have.	Ich werde,	I become.
2.	du bist,	thou art.	du hast,	thou hast.	du wirst,	thou becomest.
3.	er (sie, es) ist,	he (she, it) is.	er (sie, es) hat,	he (she, it) has.	er (sie, es) wird,	he becomes.
P. 1.	wir sind,	we are.	wir haben,	we have.	wir werden,	we become.
2.	ihr seid,	you are.	ihr habet,	you have.	ihr werdet,	you become.
3.	sie sind,	they are.	sie haben,	they have.	sie werden,	they become.

IMPERFECT TENSE.

	Sein	To Be	Haben	To Have	Werden	To Become
S. 1.	Ich war,	I was.	Ich hatte,	I had.	Ich wurde *or* ward,	I became.
2.	du warst,	thou wast.	du hattest,	thou hadst.	du wurdest *or* wardst,	thou becamest.
3.	er war,	he was.	er hatte,	he had.	er wurde *or* ward,	he became.
P. 1.	wir waren,	we were.	wir hatten,	we had.	wir wurden,	we became.
2.	ihr waret,	you were.	ihr hattet,	you had.	ihr wurdet,	you became.
3.	sie waren,	they were.	sie hatten,	they had.	sie wurden,	they became.

PERFECT TENSE.

	Sein		To Be	Haben		To Have	Werden		To Become
S. 1.	Ich bin	gewesen	I have been.	Ich habe	gehabt	I have had.	Ich bin	geworden	I am become.
2.	du bist		thou hast been.	du hast		thou hast had.	du bist		thou art become.
3.	er ist		he has been.	er hat		he has had.	er ist		he is become.
P. 1.	wir sind		we have been.	wir haben		we have had.	wir sind		we are become.
2.	ihr seid		you have been.	ihr habet		you have had.	ihr seid		you are become.
3.	sie sind		they have been.	sie haben		they have had.	sie sind.		they are become.

PLUPERFECT TENSE.

	Sein		To Be	Haben		To Have	Werden		To Become
S. 1.	Ich war	gewesen	I had been.	Ich hatte	gehabt	I had had.	Ich war	geworden	I was become.
2.	du warst		thou hadst been.	du hattest		thou hadst had.	du warst,		thou wast become.
3.	er war		he had been.	er hatte		he had had.	er war		he was become.
P. 1.	wir waren		we had been.	wir hatten		we had had.	wir waren		we were become.
2.	ihr waret		you had been.	ihr hattet		you had had.	ihr waret		you were become.
3.	sie waren		they had been.	sie hatten		they had had.	sie waren		they were become.

FUTURE TENSE.

	Sein		To Be	Haben		To Have	Werden		To Become
S. 1.	Ich werde	sein	I shall *or* will be.	Ich werde	haben	I shall have.	Ich werde	werden	I shall become.
2.	du wirst		thou shalt *or* wilt be.	du wirst		thou wilt have.	du wirst		thou wilt become.
3.	er wird		he shall *or* will be.	er wird		he will have.	er wird		he will become.
P. 1.	wir werden		we shall *or* will be.	wir werden		we shall have.	wir werden		we shall become.
2.	ihr werdet		you shall *or* will be.	ihr werdet		you will have.	ihr werdet		you will become.
3.	sie werden		they shall *or* will be.	sie werden		they will have.	sie werden		they will become.

FUTURE PERFECT TENSE.

	Sein		To Be	Haben		To Have	Werden		To Become	
S. 1.	Ich werde	gewesen sein	I shall have been.	Ich werde	gehabt haben	I shall have had.	Ich werde	geworden sein	I shall have	become.
2.	du wirst		thou wilt have been.	du wirst		thou wilt have had.	du wirst		thou wilt have	
3.	er wird		he will have been.	er wird		he will have had.	er wird		he will have	
P. 1.	wir werden		we shall have been.	wir werden		we shall have had.	wir werden		we shall have	
2.	ihr werdet		you will have been.	ihr werdet		you will have had.	ihr werdet		you will have	
3.	sie werden		they will have been.	sie werden		they will have had.	sie werden		they will have	

Conditional Mood.

PRESENT TENSE.

	Sein		To Be	Haben		To Have	Werden		To Become
S. 1.	Ich würde	sein	I should be.	Ich würde	haben	I should have.	Ich würde	werden	I should become.
2.	du würdest		thou wouldst be.	du würdest		thou wouldst have.	du würdest		thou wo'dst become.
3.	er würde		he would be.	er würde		he would have.	er würde		he would become.
P. 1.	wir würden		we should be.	wir würden		we should have.	wir würden		we should become.
2.	ihr würdet		you would be.	ihr würdet		you would have.	ihr würdet		you would become.
3.	sie würden		they would be.	sie würden		they would have.	sie würden		they would become.

PERFECT TENSE.

	Sein		To Be		Haben		To Have		Werden		To Become	
S. 1.	Ich würde	gewesen sein.	I should have	been.	Ich würde	gehabt haben.	I should have	had.	Ich würde	geworden sein.	I should	have become.
2.	du würdest		thou wouldst have		du würdest		thou w'ldst have		du würdest		thou wouldst	
3.	er würde		he would have		er würde		he would have		er würde		he would	
P. 1.	wir würden.		we should have		wir würden		we should have		wir würden		we should	
2.	ihr würdet		you would have		ihr würdet		you would have		ihr würdet		you would	
3.	sie würden		they would have		sie würden		they would have		sie würden		they would	

Subjunctive Mood.

PRESENT TENSE.

S. 1.	Ich sei *or* seie,	I may be.	Ich habe,	I may have.	Ich werde,	I may become.
2.	du seiest,	thou mayst be.	du habest,	thou mayst have.	du werdest,	thou mayst become.
3.	er (sie, es) sei,	he (she, it) may be.	er (sie, es) habe,	he(she, it) may have.	er (sie, es) werde,	he may become.
P. 1.	wir seien,	we may be.	wir haben,	we may have.	wir werden,	we may become.
2.	ihr seiet,	you may be.	ihr habet,	you may have.	ihr werdet,	you may become.
3.	sie seien,	they may be.	sie haben,	they may have.	sie werden,	they may become.

IMPERFECT TENSE.

S. 1.	Ich wäre,	I might be, I were.	Ich hätte,	I might have.	Ich würde,	I might	become.
2.	du wärest,	thou mightst be.	du hättest,	thou mightst have.	du würdest,	thou mightst	
3.	er wäre,	he might be.	er hätte,	he might have.	er würde,	he might	
P. 1.	wir wären,	we might be.	wir hätten,	we might have.	wir würden,	we might	
2.	ihr wäret,	you might be.	ihr hättet,	you might have.	ihr würdet,	you might	
3.	sie wären,	they might be.	sie hätten,	they might have.	sie würden,	they might	

PERFECT TENSE.

S. 1.	Ich sei	gewesen,	I may have been.	Ich habe	gehabt,	I may have	had.	Ich sei	geworden,	I may have	become.
2.	du seiest		thou mayst have been.	du habest		thou mayst have		du seist		thou mayst have	
3.	er sei		he may have been.	er habe		he may have		er sei		he may have	
P. 1.	wir seien		we may have been.	wir haben		we may have		wir seien		we may have	
2.	ihr seiet		you may have been.	ihr habet		you may have		ihr seid		you may have	
3.	sie seien		they may have been.	sie haben		they may have		sie seien		they may have	

PLUPERFECT TENSE.

S. 1.	Ich wäre	gewesen,	I might have	been.	Ich hätte	gehabt,	I might	have had.	Ich wäre	geworden,	I were become.
2.	du wärest		thou mightst have		du hättest		thou mightst		du wärest		thou wert become.
3.	er wäre		he might have		er hätte		he might		er wäre		he were become.
P. 1.	wir wären		we might have		wir hätten		we might		wir wären		we were become.
2.	ihr wäret		you might have		ihr hättet		you might		ihr wäret		you were become.
3.	sie wären		they might have		sie hätten		they might		sie wären		they were become.

FUTURE TENSE.

S. 1.	Ich werde	sein,	I shall *or* will be.	Ich werde	haben,	I shall have.	Ich werde	werden,	I shall become.
2.	du werdest		thou shalt *or* wilt be.	du werdest		thou wilt have.	du werdest		thou wilt become.
3.	er werde		he shall *or* will be.	er werde		he will have.	er werde		he will become.
P. 1.	wir werden		we shall *or* will be.	wir werden		we shall have.	wir werden		we shall become.
2.	ihr werdet		you shall *or* will be.	ihr werdet		you will have.	ihr werdet		you will become
3.	sie werden		they shall *or* will be.	sie werden		they will have.	sie werden		they will become.

FUTURE PERFECT TENSE.

S. 1.	Ich werde	gewesen sein,	I shall have been.	Ich werde	gehabt haben,	I shall have had.	Ich werde	geworden sein,	I shall have	become.
2.	du werdest		thou wilt have been.	du werdest		thou wilt have had.	du werdest		thou wilt have	
3.	er werde		he will have been.	er werde		he will have had.	er werde		he will have	
P. 1.	wir werden		we shall have been.	wir werden		we shall have had.	wir werden		we shall have	
2.	ihr werdet		you will have been.	ihr werdet		you will have had.	ihr werdet		you will have	
3.	sie werden		they will have been.	sie werden		they will have had.	sie werden		they will have	

Imperative Mood.

S. 2.	Sei du,	be thou.	Habe du,	have thou.	Werde du,	become thou.
3.	sei er,	let him be.	habe er,	let him have.	werde er,	let him become.
P. 1.	seien wir,	let us be.	haben wir,	let us have.	werden wir,	let us become.
2.	seid ihr,	be ye.	habet ihr,	have you.	werdet ihr,	become you.
3.	sei(e)n sie,	let them be.	haben sie,	let them have.	werden sie,	let them become.

Infinitive Mood.

Pres.	Sein,	to be.	Haben,	to have.	Werden,	to become.
Perf.	Gewesen sein,	to have been.	Gehabt haben,	to have had.	Geworden sein,	to have become.
Fut.	Sein werden,	to be about to be.	Haben werden,	to be about to have.	Werden werden,	to be about to become.

Participles.

Pres.	Seiend,	being (*seldom used*).	Habend,	having (*seldom used*).	Werdend,	becoming, growing.
Perf.	Gewesen,	been.	Gehabt,	had.	Geworden (worden),*	become, grown.

*Werden, when used as an auxiliary verb, forms the past participle worden; when used as an intransitive verb, geworden.

In the above tenses the words outside of the brackets are to be used at the end of each of the lines inclosed in the bracket; *e.g.* Ich bin gewesen, du bist gewesen, &c. The form given for the third person plural is now almost invariably used for the second, and had better be at once adopted.

EXERCISE.

(Translate into German.)

You are. He was. You have been. They had been. They shall be. We shall have been. He would be. He would have been. I may be. You might be. He may have been. If (wenn) thou shalt be (subjunctive). Let him be.

You have. He had. You have had. They have had. They shall have. We shall have had. He would have. He would have had. I may have. You might have. He may have had. If thou shalt have. Let him have.

You become. He became. You have become. They had become. They shall become. We shall have become. He would become. He would have become. I may become. You might become. He may have become. If thou shalt become. Let him become.

The auxiliary verbs of mood are all irregular; they are not, however, defective, as in English, but have all their moods and tenses except the imperative, which could be formed, but is scarcely ever required. Their meanings are peculiar, and will be explained in next lesson. The words placed outside brackets opposite tenses must be added to each person in that tense, *e.g.* PLUPERFECT TENSE, Ich hatte gekonnt, du hattest gekonnt, &c.

AUXILIARY VERBS OF MOOD.

	Können, BE ABLE (CAN).	Dürfen, BE ALLOWED.	Mögen, MAY, TO LIKE.	Müssen, BE OBLIGED.	Sollen, BE OBLIGED.	Wollen, BE WILLING.	Lassen, LET (PERMIT).

Indicative Mood.

PRESENT TENSE.

	I am able.	I am allowed.	I may, I like.	I am obliged.	I am obliged.	I am willing.	I let.
S. 1.	Ich kann,	Ich darf,	Ich mag,	Ich muß,	Ich soll,	Ich will,	Ich lasse,
2.	du kannst,	du darfst,	du magst,	du mußt,	du sollst,	du willst,	du lässest,
3.	er kann,	er darf,	er mag,	er muß,	er soll,	er will,	er läßt,
P. 1.	wir können,	wir dürfen,	wir mögen,	wir müssen,	wir sollen,	wir wollen,	wir lassen,
2.	ihr könnt,	ihr dürft,	ihr möget,	ihr müßt,	ihr sollt,	ihr wollt,	ihr laßt,
3.	sie können,	sie dürfen,	sie mögen,	sie müssen,	sie sollen,	sie wollen,	sie lassen,

IMPERFECT TENSE.

	I was able.	I was allowed.	I might, I liked.	I was obliged.	I was obliged.	I was willing.	I did let.
S. 1.	Ich konnte,	Ich durfte,	Ich mochte,	Ich mußte,	Ich sollte,	Ich wollte,	Ich ließ,
2.	du konntest,	du durftest,	du mochtest,	du mußtest,	du solltest,	du wolltest,	du ließest,
3.	er konnte,	er durfte,	er mochte,	er mußte,	er sollte,	er wollte,	er ließ,
P. 1.	wir konnten,	wir durften,	wir mochten,	wir mußten,	wir sollten,	wir wollten,	wir ließen,
2.	ihr konntet,	ihr durftet,	ihr mochtet,	ihr mußtet,	ihr solltet,	ihr wolltet,	ihr ließet,
3.	sie konnten,	sie durften,	sie mochten,	sie mußten,	sie sollten,	sie wollten,	sie ließen,

PERFECT TENSE.

	I have been able.	I have been, &c.	I have liked.	I have been, &c.	I have been, &c.	I have been, &c.	I have let.
S. 1.	Ich habe	Ich habe	Ich habe	Ich habe	Ich habe	Ich habe	Ich habe
2.	du hast	du hast	du hast	du hast	du hast	du hast	du hast
3.	er hat	er hat	er hat	er hat	er hat	er hat	er hat
P. 1.	wir haben	wir haben	wir haben	wir haben	wir haben	wir haben	wir haben
2.	ihr habt	ihr habt	ihr habt	ihr habt	ihr habt	ihr habt	ihr habt
3.	sie haben	sie haben	sie haben	sie haben	sie haben	sie haben	sie haben
	gekonnt,	gedurft,	gemocht,	gemußt,	gesollt,	gewollt,	gelassen,

PLUPERFECT TENSE.

	I had been able.	I had been, &c.	I had liked.	I had been, &c.	I had been, &c.	I had been, &c.	I had let.
S. 1.	Ich hatte	Ich hatte	Ich hatte	Ich hatte	Ich hatte	Ich hatte	Ich hatte
2.	du hattest	du hattest	du hattest	du hattest	du hattest	du hattest	du hattest
3.	er hatte	er hatte	er hatte	er hatte	er hatte	er hatte	er hatte
P. 1.	wir hatten	wir hatten	wir hatten	wir hatten	wir hatten	wir hatten	wir hatten
2.	ihr hattet	ihr hattet	ihr hattet	ihr hattet	ihr hattet	ihr hattet	ihr hattet
3.	sie hatten	sie hatten	sie hatten	sie hatten	sie hatten	sie hatten	sie hatten
	gekonnt,	gedurft,	gemocht,	gemußt,	gesollt,	gewollt,	gelassen,

FUTURE TENSE.

	I shall be able.	I shall be allowed.	I shall like.	I shall be obliged.	I shall be obliged.	I shall be, &c.	I shall let.
S. 1.	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde
2.	du wirst	du wirst	du wirst	du wirst	du wirst	du wirst	du wirst
3.	er wird	er wird	er wird	er wird	er wird	er wird	er wird
P. 1.	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden
2.	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet
3.	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden
	können,	dürfen,	mögen,	müssen,	sollen,	wollen,	lassen,

FUTURE PERFECT TENSE.

	I shall have been able.	I shall have, &c.	I shall have, &c.	I shall have, &c.	I shall have, &c.	I shall have, &c.	I shall have let.
S. 1.	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde
2.	du wirst	du wirst	du wirst	du wirst	du wirst	du wirst	du wirst
3.	er wird	er wird	er wird	er wird	er wird	er wird	er wird
P. 1.	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden
2.	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet
3.	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden
	gekonnt haben,	gedurft haben,	gemocht haben,	gemußt haben,	gesollt haben,	gewollt haben,	gelassen haben,

Conditional Mood.

PRESENT TENSE.

	I should be able.	I should be, &c.	I should like.	I should be, &c.	I should be, &c.	I should be, &c.	I should let.
S. 1.	Ich würde	Ich würde	Ich würde	Ich würde	Ich würde	Ich würde	Ich würde
2.	du würdest	du würdest	du würdest	du würdest	du würdest	du würdest	du würdest
3.	er würde	er würde	er würde	er würde	er würde	er würde	er würde
P. 1.	wir würden	wir würden	wir würden	wir würden	wir würden	wir würden	wir würden
2.	ihr würdet	ihr würdet	ihr würdet	ihr würdet	ihr würdet	ihr würdet	ihr würdet
3.	sie würden	sie würden	sie würden	sie würden	sie würden	sie würden	sie würden
	können,	dürfen,	mögen,	müssen,	sollen,	wollen,	lassen,

PERFECT TENSE.

	I should have been able.	I should have, &c.	I should have, &c.	I should have, &c.	I should have, &c.	I should have, &c.	I should have let.
S. 1.	Ich würde	Ich würde	Ich würde	Ich würde	Ich würde	Ich würde	Ich würde
2.	du würdest	du würdest	du würdest	du würdest	du würdest	du würdest	du würdest
3.	er würde	er würde	er würde	er würde	er würde	er würde	er würde
P. 1.	wir würden	wir würden	wir würden	wir würden	wir würden	wir würden	wir würden
2.	ihr würdet	ihr würdet	ihr würdet	ihr würdet	ihr würdet	ihr würdet	ihr würdet
3.	sie würden	sie würden	sie würden	sie würden	sie würden	sie würden	sie würden
	gekonnt haben,	gedurft haben,	gemocht haben,	gemußt haben,	gesollt haben,	gewollt haben,	gelassen haben,

Subjunctive Mood.

PRESENT TENSE

	I may be able.	I may be allowed.	I may.	I may be obliged.	I shall.	I may be willing.	I may let.
S. 1.	Ich könne,	Ich dürfe,	Ich möge,	Ich müsse,	Ich solle,	Ich wolle,	Ich lasse,
2.	du könnest,	du dürfest,	du mögest,	du müssest,	du sollest,	du wollest,	du lassest,
3.	er könne,	er dürfe,	er möge,	er müsse,	er solle,	er wolle,	er lasse,
P. 1.	wir können,	wir dürfen,	wir mögen,	wir müssen,	wir sollen,	wir wollen,	wir lassen,
2.	ihr könnet,	ihr dürfet,	ihr möget,	ihr müsset,	ihr sollet,	ihr wollet,	ihr lasset,
3.	sie können,	sie dürfen,	sie mögen,	sie müssen,	sie sollen,	sie wollen,	sie lassen,

IMPERFECT TENSE.

	I might be able.	I might be, &c.	I might.	I might be, &c.	I might be, &c.	I might be, &c.	I might let.
S. 1	Ich könnte,	Ich dürfte,	Ich möchte,	Ich müßte,	Ich sollte,	Ich wollte,	Ich ließe,
2.	du könntest,	du dürftest,	du möchtest,	du müßtest,	du solltest,	du wolltest,	du ließest,
3.	er könnte,	er dürfte,	er möchte,	er müßte,	er sollte,	er wollte,	er ließe,
P. 1.	wir könnten,	wir dürften,	wir möchten,	wir müßten,	wir sollten,	wir wollten,	wir ließen,
2.	ihr könntet,	ihr dürftet,	ihr möchtet,	ihr müßtet,	ihr solltet,	ihr wolltet,	ihr ließet,
3.	sie könnten,	sie dürften,	sie möchten,	sie müßten,	sie sollten,	sie wollten,	sie ließen,

PERFECT TENSE.

	I may have been able.	I may have, &c.	I may have liked.	I may have, &c.	I may have, &c.	I may have, &c.	I may have let.
S. 1.	Ich habe	Ich habe	Ich habe	Ich habe	Ich habe	Ich habe	Ich habe
2.	du habest	du habest	du habest	du habest	du habest	du habest	du habest
3.	er habe	er habe	er habe	er habe	er habe	er habe	er habe
P. 1	wir haben	wir haben	wir haben	wir haben	wir haben	wir haben	wir haben
2.	ihr habet	ihr habet	ihr habet	ihr habet	ihr habet	ihr habet	ihr habet
3.	sie haben	sie haben	sie haben	sie haben	sie haben	sie haben	sie haben
	} gekonnt,	} gedurft,	} gemocht,	} gemußt,	} gesollt,	} gewollt,	} gelassen,

PLUPERFECT TENSE.

	I might have been able.	I might have, &c.	I might have, &c.	I might have, &c.	I might have, &c.	I might have, &c.	I might have let.
S. 1.	Ich hätte	Ich hätte	Ich hätte	Ich hätte	Ich hätte	Ich hätte	Ich hätte
2.	du hättest	du hättest	du hättest	du hättest	du hättest	du hättest	du hättest
3.	er hätte	er hätte	er hätte	er hätte	er hätte	er hätte	er hätte
P. 1.	wir hätten	wir hätten	wir hätten	wir hätten	wir hätten	wir hätten	wir hätten
2.	ihr hättet	ihr hättet	ihr hättet	ihr hättet	ihr hättet	ihr hättet	ihr hättet
3.	sie hätten	sie hätten	sie hätten	sie hätten	sie hätten	sie hätten	sie hätten
	} gekonnt,	} gedurft,	} gemocht,	} gemußt,	} gesollt,	} gewollt,	} gelassen,

FUTURE TENSE.

	If I shall be able.	If I shall be, &c.	If I shall like.	If I shall be, &c.	If I shall be, &c.	If I shall be, &c.	If I shall let.
S. 1.	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde
2.	du werdest	du werdest	du werdest	du werdest	du werdest	du werdest	du werdest
3.	er werde	er werde	er werde	er werde	er werde	er werde	er werde
P. 1.	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden
2.	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet
3.	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden
	} können,	} dürfen,	} mögen,	} müssen,	} sollen,	} wollen,	} lassen,

FUTURE PERFECT TENSE.

	If I shall have been able.	If I shall have, &c.	If I shall have, &c.	If I shall have, &c.	If I shall have, &c.	If I shall have, &c.	If I shall have let.
S. 1.	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde	Ich werde
2.	du werdest	du werdest	du werdest	du werdest	du werdest	du werdest	du werdest
3.	er werde	er werde	er werde	er werde	er werde	er werde	er werde
P. 1.	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden	wir werden
2.	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet	ihr werdet
3.	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden	sie werden
	} gekonnt haben,	} gedurft haben,	} gemocht haben,	} gemußt haben,	} gesollt haben,	} gewollt haben,	} gelassen haben,

ENGLISH GRAMMAR AND COMPOSITION.

CHAPTER V.

THE VERB: CLASSIFICATION, CHARACTERISTICS, CONJUGATIONS, INFLEXIONS, ETC.

Experience shows man that some objects in nature possess qualities only of a conditioning and others of a causative nature—some sufficient to impress, others efficient in producing change. This distinction in experience he is anxious to indicate in language. Hence he uses for the signs of such qualities as may be characterized as quiescent—adjectives; and for those which are active—verbs. Almost the main purpose of speech is to announce, describe, and explain the action and interaction which constitute events—the changes produced in our sensations, feelings, volitions, &c., by the motion, action, or effective power of surrounding existences, or those producible by us in them. Without a word suggestive of the extrinsic efficient powers of persons and things, speech as we understand it would be all but impossible. On this account the word which implies, informs us about, or makes statements concerning the condition or operation of the powers of natural objects or men, has received the distinctive appellation of *the* verb (Lat. *verbum*, a word), as being essential to discourse. The verb may therefore be regarded as that special part of speech by which several other separate words are conjoined into one single complete logical expression or compound word, constituting a sentence. Owing to its importance in speech, a good deal of ingenuity has been employed to increase the definiteness of the signification and specialize the expressiveness of the verb. Its development has been such that it is now in most languages so employed as to co-express the following—besides other—different ideas:—

(1) An attribute or power, existing either in an exercised or unexercised condition; as, I think = I am a thinking being now exercising that power.

(2) A connection between that power and some person or thing in whom (or which) it inheres or manifests itself; as, He runs = the power of running exists in and is exercised by him.

(3) An assertion—either direct or indirect—that this function is really, in this connected manner, existent or active; as, He lives, We are, They love, &c.

In this sense, then, a verb may be defined as a word which makes affirmation or assertion concerning (1) being (existence), (2) doing (exercised power), or (3) suffering (having energy exerted upon one by another); as (1) I am, exist, become, grow, &c.; (2) I run, speak, advise, &c.; (3) I am advised, struck, convinced, &c.

Of verbs which denote *being* some are (1) substantive, indicating existence; (2) conditional, implying state of being; as, I am, stand, sit, run, &c. Of those which indicate *doing* some are (1) transitive, expressive of actions or influences which pass over into and affect something else; (2) intransitive, including verbs referring to feelings, emotions, and actions contained within the agent, and not directed to or operating upon an object; as (1) I love, strike, teach; (2) I freeze, rejoice, dwell, dream, &c. Nothing in the form of the verb supplies us with the means of determining between transitive and intransitive ones: the use made of the verb, *i.e.* the special signification given to it in any sentence, alone decides that distinction. We may say, "That man speaks too often," in which case the verb is intransitive; or we may state, "Elihu Burrit spoke many languages," in which it is transitive. Similarly we may say, "The mill-wheel moves" (intrans.), and "Such sights always move me" (trans.); "Her breast heaves with emotion" (intrans.); "He heaves that huge stone easily" (trans.)

Active-transitive verbs are those which make assertions regarding actions performed by an agent upon an object other than the agent, by which the former influences the latter; as *send, describe*, &c.

Active-intransitive verbs are those which relate to actions wholly confined within the agent, and consequently not influencing an object external to the agent; as *walk, stand, sit, feed*, &c.

The difference between transitive and intransitive verbs is not in general indicated by form, but known by function; *e.g. lay, raise*, and *set* are transitive, *lie, rise*, and *sit* are intransitive. An intransitive verb may be changed into a transitive one by subjoining or prefixing a preposition; as *laugh, laugh at; come, overcome; speak, bespeak, speak for*, &c. We often, however, employ verbs of either nature, just as suits our purpose; as He walked up and down the street; He walked the horse [=caused the horse to walk] up and down the street.

Passive verbs are such as indicate the enduring of some action, either pleasing or painful, by the subject; there are, however, strictly speaking, no passive verbs in the English language; as, I am taught.

Neuter verbs are such as, being neither active nor passive, make affirmations regarding attributes or states of being without expressing either action or endurance; as *dwell, dream, rage, come*, &c.

Reflexive verbs are those in which the action passes from and returns to, so as to act upon, the agent; as, I dress myself; Thou hast undone thyself, &c.

These are, however, in reality metaphysical rather than grammatical distinctions, none of them having any formal specializing signs. The entire grammatical power of each verb really depends on the meaning with which it is used.

THE CONJUGATION OF VERBS.

The arrangement of verbs in classes, according to the mode of forming their inflected tenses, is sometimes called *Conjugation*. English verbs are in this sense divided into two classes or conjugations.

(1) The *Irregular* or *Strong*, when the root is changed with or without a suffix in the past tense and in the perfect participle.

(2) The *Regular* or *Weak*, when the root is unchanged and a suffix is added to the past tense and the past participle.

A regular verb forms its past tense and past participle by adding *d* or *ed* to the present—*e.g. love, loved, loved; turn, turned, turned.*

An irregular verb forms its past tense or past participle by a change of vowel within itself—as *rise, rose, risen; sing, sang, sung*. Some take the suffix *n* or *en*.

To conjugate a verb, however, more generally means to mention all the variations of mood, tense, number, and person which it is capable of taking.

Some verbs have (1) both the regular and the irregular forms, some have (2) two forms for the past tense, and others (3) two for the past participle. Such verbs are termed Redundant—as, *Present*, light; *Past*, lit or lighted; *Past Participle*, lit or lighted.

Some verbs are not complete in their conjugation; they want one or more of their principal parts. Such verbs are called Defective—*e.g.*

Beware	—	—	Ought	—	—
Foredo	—	foredone	Quoth	quoth	—
Forgo	—	forgone	Wis	wist	—
List	list	—	Wit *or* wot	wot	—

Impersonal verbs are such as denote the occurrence of a fact or action without indicating any person as the subject or actor; as, It is warm, it rains, it thundered.

Voice is the technical term which grammarians employ to indicate the different species of verbs, viz. active-transitive, active-intransitive, passive, neuter, and reflexive.

Mood is a particular form of the verb indicating the manner in which the assertion made by it is modified.

There are, it is usually said, five moods—viz. Indicative, Potential, Subjunctive, Imperative, and Infinitive.

The indicative simply asserts (or asks a question); as, I love, Do I love?

The potential mood makes assertions implying possibility, liberty, power, will, duty, or obligation; as, He may ride, I can walk, We shall obey. Or it makes inquiries concerning them; as, May I say? Can he walk? Should I obey?

The subjunctive mood makes conditional assertions, the condition being indicated by a conjunction, either expressed or understood; as, If he come I will go, When he yields I may consent.

The subjunctive mood is therefore employed only in subordinate sentences.

The imperative indicates desire, which may either be expressed in entreaty, command, exhortation, &c.; as, Go! Come!

The infinitive is the name of the action denoted by the verb unlimited by any mention of person. It is frequently, if not always, equivalent to a noun.

The verb in all its parts is really indicative or assertive. The names imperative and infinitive may, however, be retained as convenient appellations for two particular parts of the verb; and potential may be regarded as an appropriate name for those parts of the compound verb which indicate or assert power and liberty. The subjunctive is now almost obsolete. It is manifest that, wherever the form so called is used, the peculiarity is occasioned, not so much by the fact of its being subjoined to "if" and similar conjunctions, as by the character of the idea intended to be expressed when we use it. It has, except in the verb *to be*, no distinct form of inflexion.

Verbs admit of inflexion to express number, person, and time. They are also, generally, said to admit of inflexion to form the imperfect and perfect participles.

The imperfect participle is formed by adding *ing* to the verb, and denotes that the verbal action or state is going on; as, *loving, walking.*

The perfect participle is, in regular verbs, formed by adding *d* or *ed*, and denotes that the verbal action or state is finished; as *loved, walked.* In irregular verbs they take different forms. This will be fully explained subsequently.

Strictly speaking, participles are not parts of the verb, as they do not imply affirmation, but are in their use merely adjectives.

A participle is, however, a word formed from a verb; and it performs the functions partly of a verb and partly of an adjective. Being formed from verbs the participles denote action either done or suffered; but participles often lose their verbal character, and become pure adjectives. They are then called participial adjectives, and as such they modify nouns.

Participial adjectives, like others, can be compared, while participles cannot. In the sentence, "I saw a man moving a stone," *moving* is a participle, and cannot be compared; in "I never saw a more moving spectacle," *moving* is an adjective, and is compared.

The participle in *ing* is frequently used to perform the office of a noun. When used in this manner it is called a verbal or participial noun; as, Walking is good for the health.

Participial nouns retain to some extent verbal power; as, Thus, working mischief, on they went.

Tense denotes the time implied in the verb. There are no other real tense-inflexions in English verbs, except those

which imply present or past time. The present tense represents an action or state in present time. The past tense indicates that the action or state belonged to a time past.

A great deal of metaphysical subtlety has been expended on the explanation of tense. Time is mentally divisible into many parts, of which the following threefold analysis is the primary, viz.—

2. Past. 1. Present. 3. Future.

The present implies *simultaneity* with a constantly changing but consciously known *now*. The past implies *anteriority* to any special point regarded as present. The future implies *posteriority* to any special point regarded as present.

The English recognize the past as a possession, the present as a fact, and as regards the future, in respect to time, they seem inclined to agree with the old Scotch song—

> "The present minute is our ain,
> The neist we never saw."

English grammar employs inflexion for the present and the past; it uses an auxiliary for the future. The past tense is used to indicate (1) a single act: I found this stone; (2) a repeated act: They came daily to the sea-side; (3) a habitual act: He gave himself up to indolence; (4) a constant condition: He guarded her with care; (5) the customary employment of a person: He composed readily. The present tense we use to denote (1) a single act done now: She falls; (2) an unchanging fact: The earth revolves; (3) a repeated act: Ambition glorifies my aims; (4) a habitual state: We fear dishonour, not defeat; (5) a constant condition: The Bass stands out amid the waves; (6) the exercise of some power; She sings, plays, dances, draws, and recites; (7) a vivid mode of stating historical incidents: Richard II. descends, Bolingbroke ascends; (8) a nearly approaching (future) fact: I am glad she comes to-night; (9) a somewhat distant and indefinite future: Till you promise amendment I cannot forgive.

Besides time, however, tense implies that the action referred to is finished or unfinished, and hence tenses are often spoken of as perfect or imperfect. I write, I am writing, refer to a present unfinished action; I wrote, I was writing, to past actions, unfinished at the time spoken of. I have written, to a newly-finished, *i.e.* a perfected action; I had written, to an action perfected sometime previously, and therefore more than perfect.

Actions intended by us to be done must be performed subsequently to the formation of the intention, and must therefore be held to refer to the future (1) near: I am going to write; (2) remote: I shall write. A present duty must be done in a future time, and may refer therefore to the future: I should go, I ought to obey.

Number denotes whether the assertion is made regarding one or more; as, I run, We leave, &c.

Person refers to the subject of the verb, whether speaking, addressed, or spoken about; as, I move, Thou goest, He speaks, They laugh.

Verbs may be usefully, in our own minds, divided into two classes—viz. general and specific.

General verbs are such as express the necessary categories of the intellect regarding assertions—*i.e.* all the common and ordinary methods of thinking of objects; they are—

PRESENT TENSE.	PAST TENSE.	SIGNIFICATION.
Am	Was	Existence or being
Can	Could	Power or ability
Do	Did	Emphatic action or assertion
Have	Had	Possession
Let	—	Permission [asked, granted]
May	Might	Liberty
Must	—	Necessity
Shall	Should	Duty or obligation [futurity]
Will	Would	Volition or intention [futurity]

and are commonly denominated auxiliary verbs. Ought, need, and dare, when used without personal inflexion, may also be considered general verbs.

All other verbs, as they express assertions of a more special and limited nature, may be regarded as specific.

THE FORMS OF CONJUGATION OF THE GENERAL—*i.e.* AUXILIARY—VERBS.

BE.

Indicative.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I am	We are.	1. I was,	We were.
2. Thou art,	You are.	2. Thou wast,	You were.
3. He is,	They are.	3. He was,	They were.

Subjunctive.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I be,	We be.	1. I were,	We were.
2. Thou be.	You be.	2. Thou wert,	You were.
3. He be.	They be.	3. He were,	They were.

Imperative Mood.

Sing. 2. Be thou. *Plur.* 2. Be ye or you.

Infinitive.

Present. To be. *Pres. Pref.* To have been.

Participles.

Present. Being. *Pres. Pref.* Having been.

Passive Participle. Been.

Have.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I have,	We have.	1. I had,	We had.
2. Thou hast,	You have.	2. Thou hadst,	You had.
3. He has (hath),	They have.	3. He had,	They had.

Infinitive. To have. *Participles.* Having, had.

Do.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I do,	We do.	1. I did,	We did.
2. Thou dost, doest	You do.	2. Thou didst,	You did.
3. He does (doth),	They do.	3. He did,	They did.

Will.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I will,	We will.	1. I would,	We would.
2. Thou wilt,	You will.	2. Thou wouldst,	You would.
3. He will,	They will.	3. He would,	They would.

Shall.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I shall,	We shall.	1. I should,	We should.
2. Thou shalt,	You shall.	2. Thou shouldst,	You should.
3. He shall,	They shall.	3. He should,	They should.

May.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I may,	We may.	1. I might,	We might.
2. Thou mayest,	You may.	2. Thou mightst.	You might.
3. He may,	They may.	3. He might.	They might.

Can.

PRESENT TENSE. *Sing.*	*Plur.*	PAST TENSE. *Sing.*	*Plur.*
1. I can,	We can.	1. I could,	We could.
2. Thou canst,	You can.	2. Thou couldst,	You could.
3. He can,	They can.	3. He could,	They could.

General verbs are most commonly used in combination with other verbs, which are so joined with them as to limit their signification. Thus, if I say "I can," I affirm that I have power or ability in general, without limiting it to any particular kind or application of the power. But if I add the specific verb *write*, and say "I can write," I restrict my assertion to my power of performing the art of *writing*.

General verbs, when combined with other verbs, form compound verbs; *e.g.* I have loved, I had written, I shall have walked, I might have been struck, are compound verbs. General verbs have obtained the name of *auxiliary* verbs because they are used principally to form compound verbs.

The power of forming compound verbs is of essential importance, to enable us to express all those additional modifications which languages of a more artificial structure express by inflexion.

In consequence of the facility afforded by general verbs for forming compound tenses, the English language, though limited in tenses formed by inflexion, is rich beyond most languages in tenses formed by combination. When thus combined with other verbs, general verbs serve the same purposes as the inflexions of the simple verb in such languages as Latin and Greek.

The verb *to be* is the only instance in which, in the English language, the infinitive is different in form from the present tense. It is also the only English verb which has a conditional *form*. In the case of all other verbs, the form, when it occurs, is purely elliptical. Thus, "If he say so, it is well," is an ellipsis for "If he shall say so." "Though he slay me, yet will I trust him," is an ellipsis for "Though he should slay me." The present tense, *I be, thou beest*, &c., is used by old writers; and it is still occasionally used (with perhaps the exception of beest) when doubt or contingency is to be expressed. Thus, "If thou be the Son of God, cast thyself down." Though both Shakspeare (2 "Henry VI.," III. ii. 295) and Milton ("Paradise Lost," I. 84) use *beest*, it is now quite obsolete among writers.

In ordinary speech or composition the second person singular is never used except in (1) addressing the Supreme Being, and (2) sometimes in poetry or impassioned prose. *You* is in general the form of the second personal pronoun plural now used. Except in poetry or poetic prose we seldom make use of *ye*. The forms *hath, doth, loveth*, in the third person singular, are seldom employed. *Has, does, loves* are the usual forms, except in pulpit oratory, antique style, or poetry.

All the modifications of tense or mood are made by the aid of these general verbs:—

Am, when joined to the present participle, composes the progressive form of the indicative, but when connected with the past participle, it constitutes the passive voice.

Can and *may*, when joined to the root-form of the verb, compose the present and past of what is called the potential mood.

Have, joined to the past participle of any verb, forms the perfect and pluperfect indicative.

Do, added to the root-form of the verb, constitutes the emphatic indicative.

Must, prefixed to the root-form of any verb, makes the present potential.

Shall and *will*, when joined in their present tenses to the root-form of any verb, constitute the future indicative. Their past tenses, similarly conjoined, form the past of the potential.

The proper use of the auxiliaries *shall* and *will* is exhibited in the following formula—

Futurity dependent on the will of the speaker.	I will,	You shall.
	—	He shall.
	We will,	They shall.
Futurity independent of the will of the speaker.	I shall,	You will.
	—	He will.
	We shall,	They will.

It would be of great advantage were the student to convince himself of the correctness of the above observations by an examination of the classical form of verb inflexion which is subjoined, in order that by a full presentation of the whole form of affirmation the use of verbs may become perfectly understood, and that the nature of the construction of sentences may be more readily comprehended.

A PARADIGM OF THE CLASSICAL FORM OF CONJUGATING THE VERB.

ACTIVE VOICE.

INDICATIVE MOOD.

PRESENT TENSE.

Simple.

Sing.	*Plur.*
1. I grieve.	1. We grieve.
2. Thou grievest.	2. You grieve.
3. He grieves (grieveth).	3. They grieve.

Progressive.

Sing.	*Plur.*
1. I am grieving.	1. We are grieving.
2. Thou art grieving.	2. You are grieving.
3. He is grieving.	3. They are grieving.

Emphatic.

Sing.	*Plur.*
1. I do grieve.	1. We do grieve.
2. Thou dost grieve.	2. You do grieve.
3. He does grieve.	3. They do grieve.

PAST OR IMPERFECT TENSE.

Simple.

Sing.	*Plur.*
1. I grieved.	1. We grieved.
2. Thou grievedst.	2. You grieved.
3. He grieved.	3. They grieved.

Progressive.

Sing.	*Plur.*
1. I was grieving.	1. We were grieving.
2. Thou wast grieving.	2. You were grieving.
3. He was grieving.	3. They were grieving.

Emphatic.

Sing.	*Plur.*
1. I did grieve.	1. We did grieve.
2. Thou didst grieve.	2. You did grieve.
3. He did grieve.	3. They did grieve.

PERFECT TENSE.

Simple.

Sing.	*Plur.*
1. I have grieved.	1. We have grieved.
2. Thou hast grieved.	2. You have grieved.
3. He has grieved.	3. They have grieved.

Progressive.

Sing.	*Plur.*
1. I have been grieving.	1. We have been grieving.
2. Thou hast been grieving.	2. You have been grieving.
3. He has been grieving.	3. They have been grieving.

PLUPERFECT TENSE.

Simple.

Sing.	*Plur.*
1. I had grieved.	1. We had grieved.
2. Thou hadst grieved.	2. You had grieved.
3. He had grieved.	3. They had grieved.

Progressive.

Sing.	*Plur.*
1. I had been grieving.	1. We had been grieving.
2. Thou hadst been grieving.	2. You had been grieving.
3. He had been grieving.	3. They had been grieving.

FUTURE TENSE.

Sing.	*Plur.*
1. I will *or* shall grieve.	1. We will *or* shall grieve.
2 Thou wilt *or* shalt grieve.	2. You will *or* shall grieve.
3. He will *or* shall grieve.	3. They will *or* shall grieve.

FUTURE PERFECT TENSE.

Sing.	*Plur.*
1. I will *or* shall have grieved.	1. We will *or* shall have grieved.
2. Thou wilt *or* shalt have grieved.	2. You will *or* shall have grieved.
3. He will *or* shall have grieved.	3. They will *or* shall have grieved.

POTENTIAL MOOD.

PRESENT TENSE.

Sing.		*Plur.*
1. I may, can, *or* must	grieve.	1. We may, can, *or* must grieve.
2. Thou mayst, canst, *or* must		2. You may, can, *or* must grieve.
3. He may, can, *or* must		3. They may, can, *or* must grieve.

PAST OR IMPERFECT TENSE.

Sing.	*Plur.*
1. I might, could, would, *or* should grieve.	1. We might, could, would, *or* should grieve.
2. Thou mightst, couldst, wouldst, *or* shouldst grieve.	2. You might, could, would, *or* should grieve.
3. He might, could, would, *or* should grieve.	3. They might, could, would, *or* should grieve.

PERFECT TENSE.

Sing.	*Plur.*
1. I may, can, *or* must have grieved.	1. We may, can, *or* must have grieved.
2. Thou mayst, canst, *or* must have grieved.	2. You may, can, *or* must have grieved.
3. He may, can, *or* must, &c.	3. They may, can, *or* must, &c.

PLUPERFECT TENSE.

Sing.	*Plur.*
1. I might, could, would, *or* sh'ld have grieved.	1. We might, could, would, *or* should have grieved.
2. Thou mightst, couldst, w'ldst, *or* shouldst have grieved.	2. You might, could, would, *or* should have grieved.
3. He might, could, would, *or* should have grieved.	3. They might, could, would, *or* should have grieved.

IMPERATIVE MOOD.

Sing.	*Plur.*
2. Grieve thou (simple).	2. Grieve ye (simple).
Be thou grieving (progressive).	Be ye grieved (progressive).
Do thou grieve (emphatic).	Do ye grieve (emphatic).

INFINITIVE MOOD.	PARTICIPLES.
To grieve (simple).	*Present*, . . Grieving.
To be grieving (progressive).	*Past*, . . . Grieved.

PASSIVE VOICE.

INDICATIVE MOOD.

PRESENT TENSE.

Sing.	*Plur.*
1. I am grieved.	1. We are grieved.
2. Thou art grieved.	2. You are grieved.
3. He is grieved.	3. They are grieved.

PAST OR IMPERFECT TENSE.

Sing.	*Plur.*
1. I was grieved.	1. We were grieved.
2. Thou wast grieved.	2. You were grieved.
3. He was grieved.	3. They were grieved.

PERFECT TENSE.

Sing.	*Plur.*
1. I have been grieved.	1. We have been grieved.
2. Thou hast been grieved.	2. You have been grieved.
3. He has been grieved.	3. They have been grieved.

PLUPERFECT TENSE.

Sing.	*Plur.*
1. I had been grieved.	1. We had been grieved.
2. Thou hadst been grieved.	2. You had been grieved.
3. He had been grieved.	3. They had been grieved.

FUTURE TENSE.

Sing.	*Plur.*
1. I shall *or* will be grieved.	1. We shall *or* will be grieved.
2. Thou shalt *or* wilt be grieved.	2. You shall *or* will be grieved.
3. He shall *or* will be grieved.	3. They shall *or* will be grieved.

FUTURE PERFECT TENSE.

Sing.	*Plur.*
1. I shall *or* will have been grieved.	1. We shall *or* will have been grieved.
2. Thou shalt *or* wilt have been grieved.	2. You shall *or* will have been grieved.
3. He shall *or* will have been grieved.	3. They shall *or* will have been grieved.

POTENTIAL MOOD.

PRESENT TENSE.

Sing.	*Plur.*
1. I may, can, *or* must be grieved.	1. We may, can, *or* must be grieved.
2. Thou mayst, canst, *or* must, &c.	2. You may, can, *or* must be, &c.
3. He may, can, *or* must be, &c.	3. They may, can, *or* must be, &c.

PAST OR IMPERFECT TENSE.

Sing.	*Plur.*
1. I might, could, would, *or* sh'ld be grieved.	1. We might, could, would, *or* should be grieved.
2. Thou mightst, couldst, w'ldst, *or* shouldst be grieved.	2. You might, could, would, *or* should be grieved.
3. He might, could, would, *or* should be grieved.	3. They might, could, would, *or* should be grieved.

PERFECT TENSE.

Sing.	*Plur.*
1. I may, can, *or* must have been grieved.	1. We may, can, *or* must have been grieved.
2. Thou mayst, canst, *or* must have been grieved.	2. You may, can, *or* must have been grieved.
3. He may, can, *or* must have been grieved.	3. They may, can, *or* must have been grieved.

PLUPERFECT TENSE.

Sing.	*Plur.*
1. I might, could, would, *or* should have been grieved.	1. We might, could, would, *or* should have been grieved.
2. Thou mightst, couldst, w'ldst, *or* sh'ldst have been grieved.	2. You might, could, would, *or* should have been grieved.
3. He might, could, would, *or* should have been grieved.	3. They might, could, would, *or* should have been grieved.

IMPERATIVE MOOD.

Sing.	*Plur.*
2. Be thou grieved.	2. Be ye grieved.

INFINITIVE MOOD.	PARTICIPLES.
Present, To be grieved.	*Present*, Being grieved.
Perfect, To have been grieved.	*Perfect*, Having been grieved.

Verbs ending in *s*, *sh*, *ch*, *x*, *z*, or *o* form the second person singular, present indicative, by adding *est*, and the third person by adding *es;* as *go*, *goest*, *goes*.

Verbs in *y* change *y* into *i* before the augments *est*, *es*, *eth*, and *ed*, but not before *ing;* as *dry*, *dries*, *drying*. *Y* with a vowel before it is not changed into *i;* as *buy*, *buys*, *buying*.

Verbs of one syllable, and those of more than one accented on the final syllable, ending in a single consonant preceded by a single vowel, double the final consonant before the augments *est*, *eth*, *ed*, *en*, and *ing*, but never before *s;* as *put* (*puts*), *puttest*, *putting; defer*, *deferred*, *deferring; forbid*, *forbidden*.

Verbs in silent *e* omit the *e* before the augments *eth*, *es*, *est*, *ed*, and *ing;* as *love*, *loves*, *loving*. *Be*, *dye*, *singe*, and *swinge*, also *shoe*, *hoe*, and *eye* retain the *e* before *ing*, to prevent their being orthographically similar to other verbs.

Verbs in *ie* change *ie* into *y* before *ing;* as *die*, *dying*.

Verbs in *c* often assume *k* before *ing* and *ed;* as *frolic*, *frolicking*.

In *do* and *go* the *o* sound is lengthened by adding *es;* as *does*, *goes*.

GEOLOGY.—CHAPTER V.

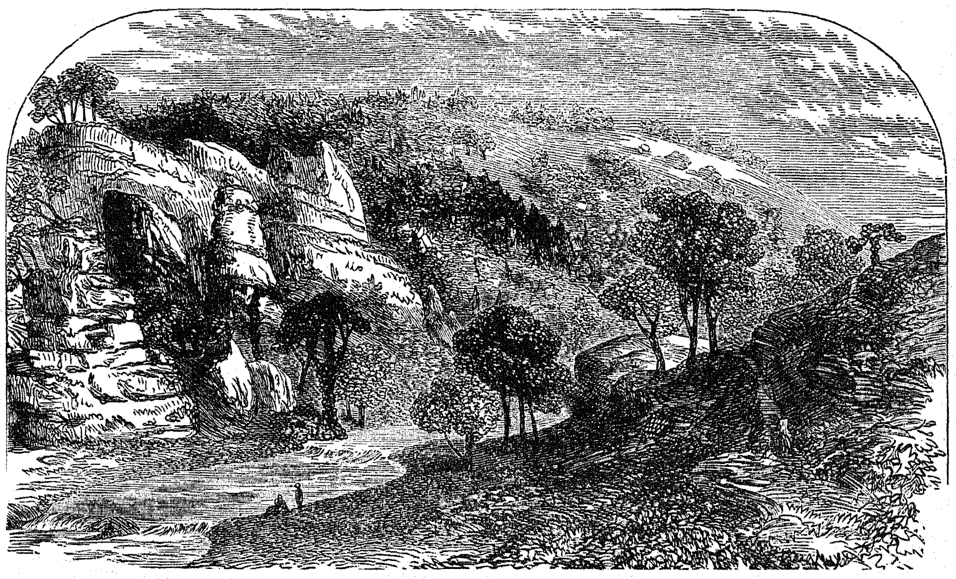
SEDIMENTARY AND IGNEOUS ROCKS—AGENTS OF GEOLOGICAL CHANGES—AIR, RAIN, FROST, ICE, ETC.

PRIMARY and direct inspection supplies us with facts. Experience makes us acquainted with change. On our observations and experience we reason, and the result is science. So far as we can trace back the history of the globe, changes have been incessantly going on in it and upon it. Geology marks the phenomena of the present and compares them with those of the past; reflects on the agencies which are productive of change now, and inquires whether those which now operate were equally or less or more intensely active in the past than in the present. Few inquiries are more importunately put by the mind than those which geological science presses on our attention—namely, by what causes have things, as they exist, been made what they are? To understand this it examines and describes the superficial crust of the earth, and soon perceives evidence enough to show that the present aspect of the globe is very unlike what its primeval features must have been. It next seeks to know what are the different natural agencies by which the contour of the land is affected, and endeavours to make some estimate of the effects which would result from the slow, sure, combined, and long-continued operation of these causes in the production of that picturesque variety of scenery which elicits so much of our interest. The splintered peaks, the rounded mounds, the rough-rent cliffs, the valley-depressions, the lacustrine hollows and the sea-basins, with all their intermediate variations, give pretty clear intimations that

the phenomena presented to the eye resulted from distinct causes, and have originated in many different ages. The perception of geologic form leads to the investigation of geological structure, and phenomenal geology ultimately results in historical geology. Scientific geology is at once logical and chronological; for any philosophical explanation of the causes which originated the land contour of the present, must incite to inquiry regarding the condition of, and the changes in, the outer crust of the earth in the past.

Atmospheric agency is a continually operative factor in producing geologic change. The causes which govern the phenomena of the air are indeed involved in uncertainty; but the power of the atmosphere as an efficient activity is sure. It disintegrates and decomposes exposed surfaces. The carbonic acid which is constantly evolved from plant and animal mingles with, and forms a potent though merely fractional portion of, the atmospheric fluid. Air is not only a medium through which moisture, heat, and electricity may act upon substances, but it exerts both chemical and mechanical influence upon the materials brought under its operation. It superinduces new combinations between its own constituent parts and those of earthy, crystalline, and metallic substances, and it also brings about the resolution of prior combinations. Hence its influence chemically may either tend to consolidation or disintegration. Kaolin clay, for example, is a hydrous silicate deposit produced by the atmospheric decomposition of the soda and potash of the felspar of granite. Whinstone or basalt are, in a humid atmosphere, liable to disintegration, and in some serpentines the crystallized structure is so much deteriorated by aerial action as to be made very ready to break in an irregular manner. In rocks held together by aggregation rather than crystallization, porosity affords great opportunity for hydration, by the absorption of moisture from the atmosphere. In such bodies gases are condensed with remarkable facility. On this account the decomposition of silicates and materials containing the oxides of metals is largely influenced, and their molecular aggregation considerably affected by air. What is technically called, among workers in stone, nitrification, tends greatly to disintegration of surface, and operates with special effect on materials having a limestone base. Stones of gypsum formation are well known to decompose rapidly under atmospheric action. Those flakes of hydrous oxide which cover almost all iron exposed to air and water show the power of these agencies; and the pains taken to prevent rust, dry or damp rot, &c., and to increase and secure by chemical silication the resistive qualities of building stones, are all evidences of the power of the atmospheric fluid as a continual coefficient in the produc tion of dust, *débris*, and surface change.

The atmosphere is not only a disintegrant in itself, it be-



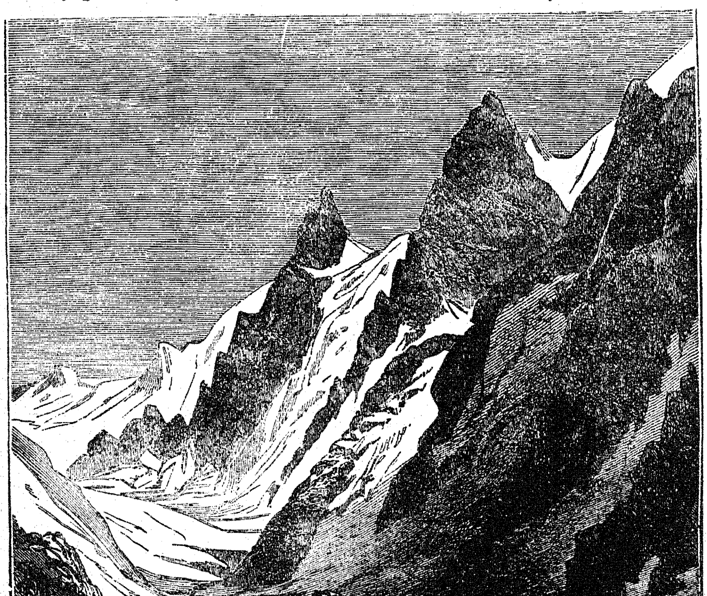
Limestone Rocks, Dovedale.

comes much more powerful in that character as a spongy retainer of moisture, and as a medium for the operation of temperature—the alternations of which, from cold to heat, and *vice versa*, have such an influence in the acceleration of decay in animal matter, vegetable tissue, wood, stone, metal, &c. We have to take account also of its power of displacement of surface, both by friction and by the removal of disintegrated material—thus leaving bare to renewed action the parts its breezes have just swept. To this add its power of aggregating drift as it sweeps or swirls along, its might in breakage when storms prevail and tempests rage, its dispersive power as wind, as well as its compressive force. The weight of a column of homogeneous atmosphere is nearly 15 lbs. on each square inch of surface, and on the whole it exerts a pressure equal to the one hundred and eighty-eight millionth part of the entire mass of the globe. Both as a dispersive and a compressive force, air acts as an agent in stratification. It disintegrates, it heaps together those loosened matters, and over these accumulated masses it exerts pressure on all that is placed under its weight.

Rain is another great worker of geological change. It exerts energy and causative influence both chemically and mechanically. A very complex play of causal activity is brought into operation upon land surfaces by water. It is not only the most universal but the most potent solvent with which we are acquainted. It diffuses and spreads the oxygen and hydrogen of which it is composed everywhere. Not in the chemist's trough alone, but in Nature's vast laboratory, its operations are apparent and important. Some of the materials of the earth extract the vapour from the atmosphere and dissolve themselves in it, and so set on foot a process preparative to stratification by yielding deposits resulting from this solubility. Acids, bases, and salts, we know, readily combine with water. The power of water as a solvent is also greatly influenced by temperature. The chemical character of bodies is often completely altered by hydration. The water of crystallization frequently rules the form taken by a salt. The fact that water—*pure* water—is seldom if ever to be had, and that even rain water is rarely found free from foreign ingredients; that spring water, mineral water, river water, and sea water all hold in solution special products of an earthy nature, shows that, as a solvent, water is constantly operating as a medium for the change of particles, their removal in place, and their carriage where they may either enter into fresh combinations or find opportunity for settling as deposits. Both chemically and mechanically geology acknowledges water as an efficient cause of change.

We have all observed the power of rain as an agent in the removal of disintegrated dust, as its falling drops wash down such particles and carry them along till they meet

with companion particles mingled with neighbouring drops. We know how these are aggregated, how they are deposited in thin laminæ where the rain filters through the soil or is absorbed into the atmosphere, leaving circle and line and layer most palpably scribbled over with its water-mark. In the rain-furrowed white limestone of Doward Hill, near Monmouth, we have a fine example of this rain-power. Even the scars of the Derbyshire Peak exemplify it. Denudation by mechanical removal, and decomposition by chemical affinity, oftentimes unite to mingle the material of layers, and most certainly indicate the reality of the power of rain. Rain defines itself in drops, organizes itself in springs, aggregates into rills, coalesces into rivulets, gathers into streams, enlarges into rivers, which flow gently or speedily towards the sea. "Continual dropping weareth away a stone." Springs, as their waters percolate through the earth, become charged with sedimentary substances. These deposit themselves on their margin or are laid along the water courses they follow. Rills, as they roll down the valley-slopes, not only carry in solution large quantities of matter, but disintegrate the surface and hurry sand grains and gravel down with them. Rivulets not only augment in volume, but force loose soil and stones forward with their currents, pulverizing the one and polishing the other.


Glaciers.

Streams not only act as irrigants, but as carriers of triturated soil, broken rock, vegetable products, animal remains, &c., and as carvers of valley hollows and rocky declivities. Rivers are powerful in detritive agents. Their torrent feeders rough-hew the lands through which, as tributaries, they plough their way to the on-sweeping streams which bear along their water-paths whatever they bring, grinding finer and rounding more deliberately, the *detritus* of the upper sources. Alluvial deposits and deltas are formed by thin *débris* thus brought from the watersheds where the rain began its operations. So the friction at once of the water and of the substances conveyed by it carve the hill-slopes, cut out gorges, engrave the hollows, and deepen the lines cut on the face alike of rock and level-land.

Water itself, besides, acquires new powers in new circumstances. Rain congealing into white crystals in the air, forms, when the temperature of the atmosphere sinks below the freezing point, that delicate snow which floats with diversity of density through the chilly air. Soft as they seem, and feathery as these falling flakes may be, they possess and exercise, when aggregated, great power. They supply, as they thaw, irrigant water; but they also occasion a large amount of detrition. When a snowfall has been heavy, and a thaw comes suddenly, it covers the hill-sides with runnels and swells the rivers into torrents. These torrents carry down the breakage of former storms, and loosen boulders preparatory to their being borne down subsequently, when other snowfalls have accumulated similar water-forces. When snow accumulates on the top of a mountain whose sides slope steeply, its weight becomes so great that it cannot retain its place on the inclined plane of the declivity, and then a snow-slip or avalanche occurs. Snow may drift from one acclivity to another, then slip with great volume and inflict much damage on the low-lying neighbourhood. After regelation it may combine into large and dangerous balls. These, packed on the slope, prone to move even by their own weight, may have an impetus given to them by the wind, and being set in motion rush furiously in their downward course, causing destruction and exciting dismay. Or it may be that, on lower lands and less steep acclivities, the snow, having lingered long, is softened into water at its base, and the entire mass moves, like a great heavy tremendous plane, down the mountain-side into the ravine hollows. By their weight, their accelerated force, their terrible friction, these avalanches rasp and grind the sloping sides, and go crashing, with all the ruin they cause, into the gorges that gape below.

Frost transforms water into ice. Water, in thus solidifying, expands nearly one-ninth of its own bulk or volume. When water, therefore, lodges in cracks, crevices, or slightly disparted lines of stratification, and freezes, it acquires a mighty wedge-like power of cleavage and breakage. It loosens, disrupts, and splinters the hardest materials, and makes them ready to be swept down by the avalanche, to fall by their own weight, or to be toppled over with destroying might from their high eminence to the level plain. Ice-fracture subdues the hardest rock. If once the trickling ooze finds admittance into any cranny or opening where it may rest until the frost-king exerts his power, we find that feats surpassing the skilled might of the quarrier are performed with an ease as extraordinary as the results are striking. Frost is the great rock-splitter, which sends the huge boulder masses adrift, and makes them ready for propulsion to far distances.

Ice formed on lofty mountains above the snow-line takes the form of glaciers. These huge masses of snowy material, converted into ice in its descent from higher to lower regions are even yet the puzzle of science. We know, however, enough regarding their phenomena to understand that glacial action is a very distinct and powerful agent in the sculpturing of the contours of the land surface of the globe. The sliding motion of such mighty masses of glacified snow; the polishing, grooving, and striation which their motion produces; their accumulation of masses of stones and other *débris*, which form lateral, medial, and terminal *moraines*, or get dropped into eroded rocky beds as *moulins* and giants' kettles; their transportation of rock-fragments and blocks of stone; their widening and deepening of combes, corries, glens, lake-hollows, and valleys; and their rounding and smoothing down of the rougher features of crags and scaurs—are all results of which geology takes account.

One of the most readily noticeable of erosive powers is the sea with its wearing action of wave and tide. The ocean exceeds the land in spacial boundary, and it sweeps and eddies round every shore with constancy of motion and triturating

energy. Though ever busy, yet it does not, perhaps, on the whole wield so real and definite a power of denudation as the wider atmospheric sea which overarches it. Its force and friction are terrible when storms lash it; but even then it is not nearly so destructive of land surface as a tempest in the aerial regions. The sea-saw of the tidal waves, the incessant fretting of the restless billows, the unintermittent aggressiveness of its shoreward tending waters, make it indeed a strong efficient cause in changing the horizontal contour of continents and islands. There comes from it a mighty water-pressure, too, which makes the stones it dashes against the shore deal heavy blows upon whatever it strikes. The unresting sea grinds all that it sweeps along with it from low to high water mark, and each separate wave in its recurrent assaults acts like a waterfall in disintegrating power. Marine erosion is steady and obstinate, and the cavernous hollows which margin the beach, the fissured rocks into which the sea-waves have worn the battlements of cliffs, the ruptured masses into which the rushing waters have forced imprisoned air, and so compelled it to obtain escape by bursting, all prove that the rocky boundary against which the ocean contends often succumbs to its invasions. Those fragments which it tears from the rocks it works round and wears down, it polishes and grinds, it breaks into shingle or pulverizes into mud. Plateaus of deposition surround our shores, where all these spoils are laid out with stratified regularity. Thus, by the simultaneous assault of the sea upon the land, and the marine denudation thus occasioned, we get from our every-day experience an idea of the tools of nature, the weariless energy with which they are wrought, and the results to which their work tends.

Water-worn Rocks, Isle of Anglesey.

The subaerial and marine waste occasioned by air and water, and the phenomena in which their operations result, enable us in some measure to understand to what stratification is due. We see composite matter mixed with and suspended in water, after a while subsiding. The heavier and coarser detritus first sinks. The finer grains, held more completely in solution, fall gradually until layer after layer composes itself in superincumbent order. Hence we may trace in the subsided mass the material out of which rock has been formed; and the order of succession in which the most prompt to find a settlement are found, as compared with that which was lighter and therefore longer of being precipitated. All such layers or strata naturally and necessarily form a horizontal series. From the superficial soil, to be found uppermost, to the earlier deposits which lie undermost, we should therefore expect to find out, though reassorted, what the materials of denudation were, and might, from the investigation of these materials, discover the elements of those masses which had been subjected to denudation or erosion.

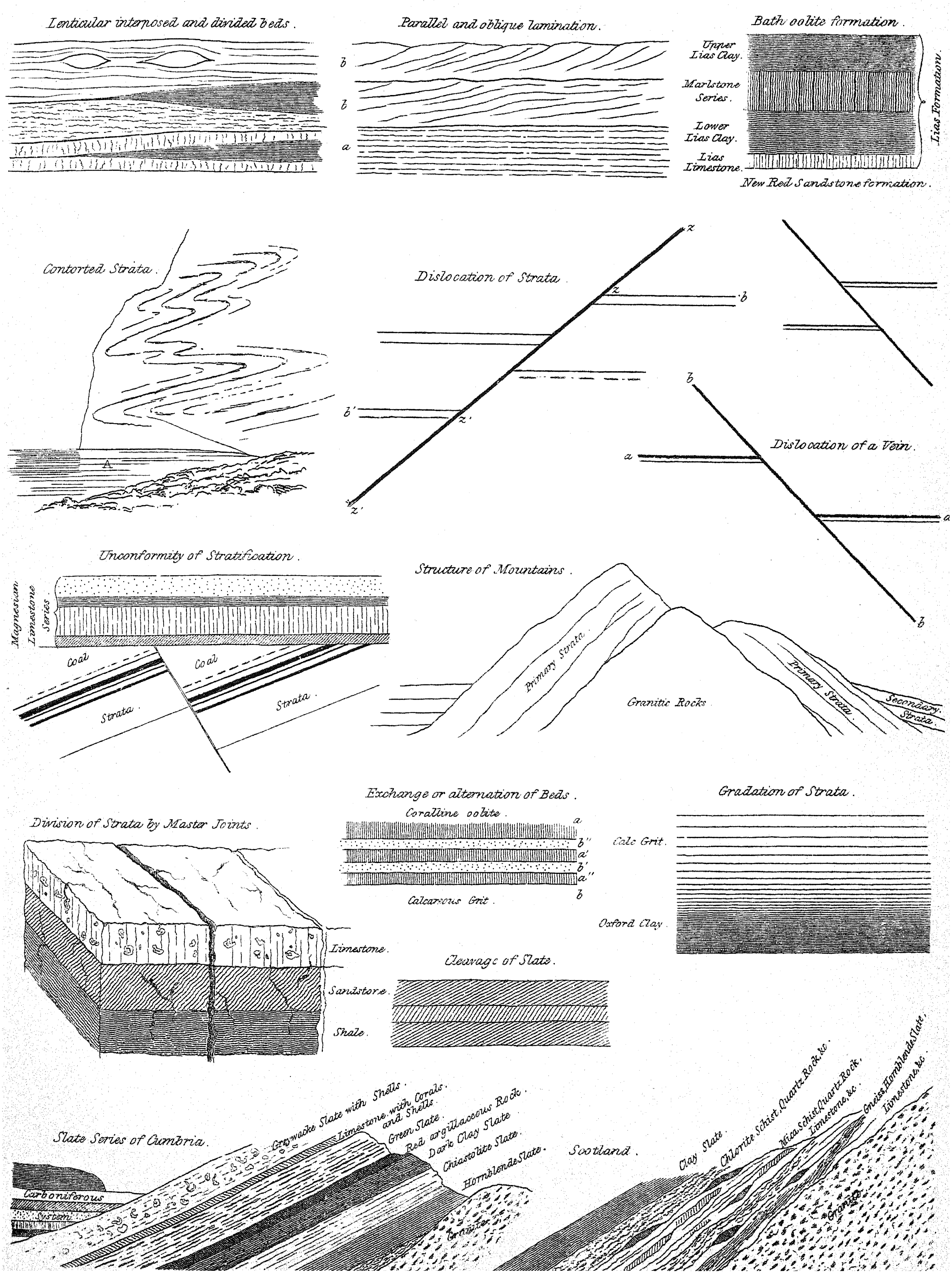
Geology, endeavouring to assign to natural causes the physical phenomena it investigates, decides that strata are deposits of matter which had been contained in water; that the sediment forming them consists of triturated matter, in most cases very finely pulverized, or otherwise reduced to most minute detritus; that strata were originally deposited in a position parallel to the surface of the water from which the deposition had been formed; that these beds, most probably subsequent to the period of their deposition, have been by pressure, contraction, and consolidation brought below the original level of their formation; that the greater part of these stratified deposits have been submerged under the ocean. They must, however, have been raised from that submerged state, and either by upheaval from below, or by depression of surface constituting reservoirs for the sea, have emerged in a crumpled, contorted state, and formed a vertically outlined land-mass.

We do not, in actual fact, find the telluric shell or earth-crust now composed of stratified rocks superimposed horizontally on one another. Much of the visible and accessible strata of the earth is quite evidently alluvial and formed of the debris of land-surfaces no longer extant. The solid materials of the earth are found folded, twisted, interverted, and tilted, showing in section singular flexure and disturbance. Amid the myriad mutations of contour which have taken place, disruption, upheaval, and depression must have been common. Volcanic eruptions and the phenomena of earthquakes make it plain that there are subterranean powers in operation which may help us to understand how these wrinklings and contortions of the earth, those tiltings and subsidences, those angular ridges and bevelled basins which give variety to the framework of continental and insular lands, have taken place, and the elevations and depressions of the earth's surface have been superinduced, by heat and pressure. The eruptive and disruptive powers known through experience to be operative in this present historic era suggest that in prehistoric periods catastrophic potencies existed and were active. Geologists use the known and familiar to explain the unknown, and strive from what *is* to comprehend what *has been*. The phenomena of volcanoes convince us of the immense transformatory power of heat—heat as a cause of expansion; of the conversion of solids into liquids and of liquids into gases; of the fusion of differing materials into conglomerate forms; heat as a chemical agent and a mode of motion; heat as the explanation of igneous, *i.e.* unstratified rocks. We see such rocks intruding into or protruding through the laminar, sedimentary, superficially deposited strata as boulder-blocks or bosses, dykes, walls, or vertical sheets of [once] molten rocks, and as tortuous veins intercalating themselves among materials of different texture and composition. We notice the structure and modes of distribution of modern lava outflows and eruptions, and find the similarity such that we infer that the igneous rocks devoid of fossils and true stratification have been fused, vitrified, or crystallized by the agency of heat. Their lithological structure, their chemical constitution, their modes of occurrence, combine to lead to the conclusion that they have, under the influence of fire, become what they are. These igneous rocks, however, are found not only intruded among sedimentary rocks, but beneath them all; and little doubt can be entertained that within but a short distance from the great superficial telluric shell of the sedimentary strata there must underlie, like an inner lining, as it were, a crust of igneous rock once fluid through heat, but now more or less solidified, shrunken, crumpled, and contorted by the cooling

GEOLOGY.

STRATIFICATION.

PLATE II.



and contracting resulting from the long-continued radiation of heat. Knowing from the phenomena of earthquakes that upheaval and subsidence are both possibilities of these disruptive incidents, we see in them the causes of table-lands and mountain-chains, of broad folds and sharp ridges, of compressed and bent valley-hollows and lacustrine basins, as well as of many of those irruptive and interruptive invasions made by the igneous rocks into the strata and systems of strata of which the earth's surface consists. Igneous rocks present in their unstratified masses no traces of organic objects—animals or plants; whereas, in sedimentary rock, we see imbedded organic remains, often most beautifully mineralized, in almost every stratum. The former seem to have been in such a state of fusion as to have thoroughly calcined any signs of organic matter, if any there was, in their intumescent molten contents; and to have ejected and injected their fluid masses, while in this state of fusion, into fissures of the superincumbent strata, or through breaches made in the earth's surface, and that these intrusive or outpoured materials subsequently became solid by refrigeration. Whether the immediate causes of these intumescent injections or ejections were primitive internal heat or chemical action, or both combined, may be debated; but it is indubitable that igneous rocks so differ from aqueous ones as to justify a classification and division of them as distinct from one another, and a consideration of their phenomena and characteristics as distinct in their features, nature, and results. The igneous rocks form but a small proportion of the entire mass of the earth's crust, though there is greater variety among them than among stratified rocks. To the phenomena of stratification we shall direct attention now, and having led observation so far into activity on its peculiarities, we shall, subsequently, bring into notice some of those peculiarities which mark out for us the interesting inquiries which may be made regarding the nature, properties, and phenomena of the unstratified basis of the telluric crust.

Unstratified rocks supply the primitive elements out of which, by triturative denudation, the plastic materials of the sedimentary strata have been derived. They form the basis on which the strata are spread, and to a large extent, by their differently contoured masses, they have governed the external outline of the land-surfaces which appear above the level of the sea. Not without change, however, have they been left. They have by erosion, abrasion, friction, denudation, grinding, upheaval, subsidence, been in their turn sculptured and escarped by wind, water, chemical and mechanical agency, till they too have had their contours changed, and present phenomena of constitution, formation, inclination, and relations, offering considerable attractions to scientific inquirers, and not without interest to those who are more consciously engrossed in extracting wealth rather than truth from stones. The origin of the earth's present superficial features is not properly to be known unless we can acquire a knowledge of the nature, constituents, conditions, and changes of igneous rocks, as well as of those more plastic and visible portions of the scenery of the globe which are due to the sedimentary formations.

We shall require, in subsequent chapters, to notice and explain the facts that the several strata which form the superficial portion of the globe are full of organic remains, and bear evidence of a great variety of phases of terrestrial life, both vegetable and animal, and perhaps to attempt to draw from these some rough idea of the enormous lapse of ages occupied by these transitions of organic existence, as well as some comprehensible conception of the forms of being associated together in the differing periods of geological time.

In the meanwhile we shall endeavour to explain some of the more salient peculiarities of the phenomena of stratification—illustrating them by references to Plate II. The fundamental definition of stratification is ideal. It is founded on the notion that loose material deposited under water must be arranged in horizontal layers parallel to the surface of the water. In calcareous and argillaceous rocks the definition and the reality, for the most part, coincide wonderfully well. In sandstone the agreement is not so marked. In them the beds are not quite persistent and regular; they often become attenuated, and thin off as if wedge-shaped; sometimes other formations interpose between different layers, and occasionally there are lenticular interspaces observable. [See Plate II., fig. 1.] Strata vary considerably, not only in thickness, but in their angular lie. In fig. 2 we see the lamination of coarse flagstone in a coal district, where *a* shows the regular laminæ, while *b b* represent deposits made at different degrees of obliquity. Above the New Red Sandstone at Bath, the Lias (*i.e.* layered) formation presents itself. The Lias limestone underlies the Lower Lias clay. Marlstone or Middle Lias intervenes, with its laminated stony beds, in which the shells of the Pectinidæ abound; and above this the argillaceous strata of the Upper Lias appears. Things are not always, however, so orderly as they are found in the Jurassic rocks. As fig. 4 shows, there are contorted strata. The squeezed crumpledness of the variously bent strata on the banks of the Lake of Lucerne, in the uplands of Chamouni, in the valley of the Lauterbrun, &c., presents singular instances of these. Again, dislocations of strata occur, and in mining districts, as *faults*, cause considerable difficulty. An idea of such fractures may be gained from the diagrams given (figs. 5 and 6). The plane of dislocation is indicated by the sloping line. These make the alternate external angles acute. The succession of the strata, exhibited horizontally on each side, is the same; their thickness and qualities are alike, and there can be no doubt that they formed one continuous plane prior to their being rent asunder and separated. A more violent disturbance than this gets the name of unconformity of strata. The coal measures in Somerset show many appearances, such as those which are shown in fig. 7, where the disrupted coal is highly inclined, and must have been tilted up or have been suddenly depressed by some intense force, even before the red marl magnesian limestone which has overspread the disparted coal in horizontal layers. When (as in fig. 8), we have a central nucleus or axis of granite (or other unstratified rock) rising up at high angles and laden on its slopes with other primary strata, upon which again secondary strata have been found, we get some idea of the manner in which, by violent upheaval, mountain districts have originated. Another peculiar phenomenon of stratification appears in fig. 9. In all rocks, fissures occur distinct from those of layer-lines or lines of cleavage. These divide the rocks into variously shaped blocks, and receive different names according to their nature. Some, following the line of direction—technically the *strike*—of the strata are called *strike-joints;* others running at right angles to these, *dip-joints;* and others still of more pronounced character, *master-joints.* These latter keep their course through great thicknesses, but imply no displacement. They are due, probably, to the shrinkage involved in the consolidation of masses after the sustained action of considerable heat. These joints have special characteristics in different strata, and are well known to workmen in quarries and mines. Strata are, in general, as we might suppose, distinguishable from one another by their mineralogical character; but when the circumstances of their deposition have been very similar they are often remarkably alike, and beds of one sort of rock are scarcely to be known, unless by experts, from beds of another sort. The Old Red Sandstone and the New Red Sandstone are in their formation very much alike. This probably arises from the recurrence of similar mechanical or chemical agencies operating in the waters of the same localities. Fig. 10 exhibits a diagram of coralline oolite, in which the strata alternate or exchange. There *b* represents calcareous grit, and *a″ a′ a* are oolitic, while *b′ b″* are sandstone formations. The gradation or passage of strata into strata is represented in fig. 11. In it the dark bluish Oxford clay is seen to shade off gradually into the yellow beds of solid calcareous grit in the way which imparts such a special appearance to the Yorkshire coast. That tendency to split along parallel lines, which in fissile structures is technically styled cleavage, is developed in fine-grained rocks, and is generally regarded as being the result of great pressure at right angles to the cleavage. It may occur in the same specimen (see fig. 14) in different angles of lamination. This is probably due to the altered incidence of superincumbent pressure much more than to difference in granular consistency. The clay slate system is a vast and variable one. Its rocks are finely grained, highly metamorphosed, and extremely

fissile. We might take as a type the slate system in which the North of England lakes are cradled. [See fig. 13.] Here the Skiddaw granite base is overlaid with gneiss, which again is covered with hornblende slate. A marl or chiastolite slate next shows itself among the lower beds. Argillaceous slate arrange themselves in three distinct members—dark, red-argillaceous, and green. On this we find a thin course of transition limestone or dark calcareous slate, and above this bed a thick series of graywacke rocks of differing colour and texture appear. Opposite this on the Plate (fig. 12) we have given an idea of the general order of the succession of rocks of the primary strata in Scotland. Every term of this series is not found co-existent in the same locality, but they are always found in this serial order. Gneiss occupies wide areas as a fundamental in Scotland. Limestone, gneiss, and hornblende are often closely interrelated in the lower beds. Quartz rocks and mica schists appear in layers of compact sedimentary sandstone, and indurated clays in close succession. The green chlorite schists, separated by layers of quartz or felspar, come next, and then the clay slate, which imparts so much of its character to the soil of Scotland. Its tenacious plastic masses are found in unkindly frequency among the coal measures. As boulder-clay it often presents extraordinary depth to the plough, and, as drift and till, requires sagacious culture. As furnishing an alluvial of a hungry and barren soil they sometimes margin the rivers. While stubborn to tillage, however, they frequently provide excellent soil for pasture and meadow lands. They, of course, owe their origin to the decomposition of minerals, and a knowledge of their character and the chemical combinations into which they most readily enter, is of great service in the successful carrying on of agricultural and pastoral husbandry. So science aids art, and knowledge increases the value of nature's bounties.

ALGEBRA.—CHAPTER IV.

ALGEBRAIC FRACTIONS—ADDITION—SUBTRACTION.

THE primary notion of a fraction is the same in algebra as in common arithmetic. An integer is a whole number—whatever may be regarded as unity; and a fraction is part of an integer. A fraction really signifies that a whole number is to be divided by the denominator, and that so many of those parts as the numerator denotes are to be taken. A fraction may mean either (1) a whole number, the numerator divided in general by a greater number than itself—*e.g.* $\frac{2}{3}$; or (2) a number of resulting parts of a unit, divided as the denominator indicates, taken as many times as the numerator denotes. These two meanings, in the latter of which $\frac{2}{3}$ means two of the equal parts into which three divides unity, are very distinct and not identical; yet they are really quite consistent the one with the other. Functionally, however, a fraction in algebra is a mode of representing a sum in division in which the numerator is the dividend and the denominator the divisor.

Algebraic fractions may be either (1) proper, (2) improper, (3) mixed, or (4) complex. *Proper* fractions are those in which the letters of the denominator indicate a higher number than the numerator; and an *improper* one is one in which the numerator indicates a higher number than the denominator—*e.g.* $\frac{a-b}{a^2-ab+b^2}$ *proper*, and $\frac{12x^2-6x+4}{3x}$ *improper*. *Mixed* fractions consist of whole and fractional terms—*e.g.* $a+b-\frac{ab}{a-b}$; and *complex* ones are such as have either (1) their denominator, (2) their numerator, or (3) both made up of fractional or mixed terms—*e.g.* $\dfrac{2a-3b+\frac{ab}{a-b}}{a^2-b^2}$.

If the numerator and the denominator of a fraction be either both multiplied by the same number or divided by the same number, the real and relative value of the fraction remains unchanged: $\frac{ax}{bx}\div x=\frac{a}{b}$ as truly as $\frac{25}{35}\div 5=\frac{5}{7}$.

$$\text{So } \frac{ab+bx}{ay+xy}\div a+x=\frac{b}{y}.$$

A fraction is multiplied by any other quantity in either of the two following ways: (1) multiplying the numerator by that quantity, or (2) dividing the denominator by that quantity; and conversely a fraction is divided by any other quantity in either of the two following ways: (1) dividing the numerator by that quantity, or (2) multiplying the denominator by that quantity—*e.g.* if it be given us to multiply $\frac{9}{26}$ by 7, it would equal $\frac{63}{26}$, while to divide the same number by 7 would equal $\frac{9}{182}$; similarly, $\frac{a}{b}\times c=\frac{ac}{b}$, and $\frac{a}{b}\div c=\frac{a}{bc}$.

Hence it follows that the two terms of any fraction may be either (1) both multiplied by the same quantity, or (2) divided by the same quantity without altering the real and relative value of the fraction. From this principle algebraists deduce the method of simplifying fractions as well as the reduction of several fractions to a common denominator. As an instance of simplification let us take $\frac{15a^5cx^3}{20a^3x^4}$. This may be held to equal $\frac{3.5.a^3.a^2.c.x^3}{4.5.a^3.x^3.x}$, in which we see we have in both the numerator and denominator the following similar parts—viz. $5.a^3.x^3$. Take these then away from both numerator and denominator, and bringing the dissimilar parts together, we have $\frac{3a^2c}{4x}$. So if we have the fraction $\frac{a^2-4b^2}{2a+4b}$, it is really equal to $\frac{(a+2b)\,(a-2b)}{2(a+2b)}$; of these parts, $a+2b$ are common to numerator and denominator, and these, being taken away from both, give us $\frac{a-2b}{2}$.

We see, then, that when we have a simple quantity to deal with, we can bring it to its lowest terms by dividing both its numerator and its denominator by any factor which is contained in, and therefore common to, both. In some cases this is discoverable by inspection; and when this is discovered we call that factor the greatest common measure of the two quantities. We learn from our experience in dealing with quantities (1) that if one quantity measures another it will measure any multiple of it; (2) that if one quantity measures two others, it will measure their sum or their difference; and (3) that if all the signs of all the terms occurring in both the numerator and denominator of a fraction are changed, the value of the fraction will be unaltered—*e.g.*

$$\frac{-ab}{-a}=\frac{+ab}{+a} \text{ and } \frac{ab}{-a}=\frac{-ab}{+a}.$$

Before fractional quantities can be added (or subtracted) they must either be, or be brought to be, fractions having the same denomination, yet retaining their own real and relative value. If they are not all of the same denomination therefore, we must change or alter them that they may be so. This process is performed by multiplying all the denominators into each other for a new denominator; and each numerator into all the denominators except its own for new numerators. Thus, if it be desired to bring the fractions $\frac{a}{b}$ and $\frac{d}{c}$ to a common denominator, we must multiply b and c together $(b\times c)$ for a new denominator bc, and next multiply a into c $(a\times c)$ and d into b $(b\times d)$ for new numerators, ac and bd. The resulting fractions having a common denominator equal to $\frac{a}{b}$ and $\frac{d}{c}$ will be $\frac{ca}{bc}$ and $\frac{bd}{bc}$.

If it should happen that a whole quantity requires to be expressed fractionally, we must multiply the whole quantity into the given denominator for a new numerator, and place the denominator under the numerator thus found. For example, let us have the whole quantity $b+\frac{a}{d}$ to bring to the denomination d, the result will be $\frac{bd+a}{d}$. If a whole quantity is to be set down as a fraction, we place the unit 1 for a denominator, thus $\frac{aa-bb}{1}$.

That fractions may be brought into the most readily workable condition, it is often requisite to reduce them to their lowest denominations. This is effected by dividing both the numerator and denominator by the greatest common measure of both—*e.g.* Let $\frac{aac-aad}{cd-dd}$ require to be brought to a lower denomination. We must divide $aac-aad$ by $cd-dd$, that is, $aac-aad \div cd-dd$, the result of which is the fraction $\frac{ac}{d}$ in its lowest denomination. Similarly, the following quantity may first be taken as an exercise in finding the greatest common measure, and may then be reduced to its lowest terms, $\frac{6a^2-2ax}{9ac-3cx}$. Of this the greatest common measure is $3a-x$, and the division being gone through the fraction in its lowest denomination appears as $\frac{2a}{3c}$.

With these preliminary remarks, definitions, and illustrations before him, the student ought to be able to follow the further teaching and exemplification which follow, as well as to perform, according to the directions given, the subjoined exercises.

Generally speaking, every fraction, whether expressed by arithmetical or by algebraical symbols, may be regarded as a quotient which results from the division of the quantity indicated by (1) the numerator, by that signified by (2) the denominator, so that the product $\frac{a}{b} \times b$ is the numerator a. And, conversely, every division is a process by which we endeavour to find out whether a given fraction can be represented by a simple expression without fractions.

The fundamental principle of all fractional operations is this: (whatever m is), $\frac{a}{b} = \frac{ma}{mb}$; that is, by performing the same operation upon both numbers, we do not change the value of the fraction. From this it directly follows:—

(1) That we may *cancel* all factors which are common to both the numerator and denominator; that is, in other words, if the same factor be found in both members, it may be expunged, and the fraction will thereby be reduced to lower terms.

$$\text{Thus } \frac{4axxy}{6aaxy} = \frac{2axy \cdot 2x}{2axy \cdot 3a} = \frac{2x}{3a} \text{ and } \frac{axx}{ax+xx} = \frac{x \cdot ax}{x(a+x)} = \frac{ax}{a+x}.$$

(2) The terms of any fraction may each be multiplied by the same quantity, and the fraction will thereby be reduced to an equivalent fraction having for denominator any multiple of the original denominator.

$$\text{Thus } \frac{a}{x} = \frac{a(a-x)}{x(a-x)} = \frac{aa-ax}{ax-xx} = \frac{aa}{xx} = \frac{100a}{100x} \text{ \&c.}$$

$$\frac{1}{a-v} = \frac{a}{aa-av} = \frac{a+1}{(a-v)(a+1)} = \frac{1 \times \frac{1}{2}}{\frac{1}{2}(a-v)} = \frac{10}{10a-10v} \text{ \&c.}$$

In this way, an expression consisting of an integral part and a fraction, may be transformed into one containing fractional terms only, having the same denominators, by performing the inverse operations of multiplication and division upon the integral part, by means of the denominator of the fractional part; *e.g.*

$$a+\frac{b}{c} = \frac{ac}{c}+\frac{b}{c} \qquad \frac{b}{x}-y = \frac{b}{x}-\frac{xy}{x}.$$

(3) Any number of fractions being given, the numerator and denominator of each may be multiplied by the denominators of all the others, or by any multiple of them, and the given fractions be thereby reduced to equivalent fractions having the same or a *common* denominator: thus, if we take the fractions $\frac{a}{b}, \frac{b}{c}, \frac{c}{d}$, and multiply the terms of $\frac{a}{b}$ by $c\,d$; those of $\frac{b}{c}$ by bd; and those of $\frac{c}{d}$ by bc, the results will be as follows:—

$$\frac{a}{b} = \frac{acd}{bcd} \qquad \frac{b}{c} = \frac{bbd}{bcd} \qquad \frac{c}{d} = \frac{bcc}{bcd}.$$

If the denominators of the given fractions contain among them a repetition of the same prime factor, such prime factor may be taken only once in reducing the fractions to others having a common denominator. Thus $\frac{a}{bx}$, and $\frac{b}{ax}$, treated as above, become $\frac{aax}{bdxx}$ and $\frac{bbx}{bdxx}$, but these fractions are manifestly reducible to $\frac{aa}{bdx}$ and $\frac{bb}{bdx}$, the prime factors of the given denominators being b, d, x.

Addition and Subtraction of Fractions.—If all the fractions requiring to be added have the same denominators, add the numerators, and under their sum as a numerator write the denominator. If all the numerators have not the same denominator, reduce them all to fractions having the same denominator, and proceed in the same way. Reduce the result to its lowest terms. *Example:* What is $\frac{a}{b}+\frac{c}{a}$ and $\frac{a}{b}-\frac{c}{d}$?

Let p and q be the values of the fractions $\frac{a}{b}$ and $\frac{c}{d}$, so that $\frac{a}{b}=p$ and $\frac{c}{d}=q$, then, by the nature of division, $a=bp$, and $c=dq$. Now, let each of the equal quantities forming these equations be multiplied respectively by d and b, so that $a=bp$ becomes $ad=bdp$, and $c=dq$ becomes $bc=bdq$; then, combining the results, we obtain

By addition.	By subtraction.
$ad+bc=bdp+bdq$	$ad-bc=bdp-bdq$.

And, dividing both sides of these equations by bd, we obtain

$$\frac{ad+bc}{bd}=p+q \qquad \frac{ad-bc}{bd}=p-q.$$

If we now put for p and q their values $\frac{a}{b}$ and $\frac{c}{d}$, we get

$$\frac{ad+bc}{bd}=\frac{a}{b}+\frac{c}{d} \qquad \frac{ad-bc}{bd}=\frac{a}{b}-\frac{c}{d}.$$

But $\frac{a}{b}=\frac{ad}{bd}$ and $\frac{c}{d}=\frac{bc}{bd}$; hence we conclude that

$$\frac{a}{b}+\frac{c}{d}=\frac{ad}{bd}+\frac{bc}{bd}=\frac{ad+bc}{bd} \text{ and } \frac{a}{b}-\frac{c}{d}=\frac{ad}{bd}-\frac{bc}{bd}=\frac{ad-bc}{bd}$$

From these formulæ it therefore appears that, the fractions being reduced to a common denominator, their $\frac{\text{sum}}{\text{difference}}$ has the $\frac{\text{sum}}{\text{difference}}$ for its numerator, and the common denominator for its denominator; and this agrees with the arithmetical rules (which will be found on page 414).

The preceding mode of establishing a principle, is a simple case of that very frequently resorted to in algebraical investigations, and should be carefully studied by the student. The following examples will afford him some practice:—

$$\frac{1}{x}+\frac{1}{y}=\frac{y}{xy}+\frac{x}{xy}=\frac{x+y}{xy} \quad \Big| \quad \frac{x}{y}-\frac{y}{x}=\frac{xx}{xy}-\frac{yy}{xy}=\frac{(x+y)(x-y)}{xy}$$

If an integral quantity be joined with a fraction, it is to be considered as a fraction whose denominator is 1, and treated accordingly. The following are mixed quantities:—

$$1+\frac{aa}{a+b}+\frac{b}{a}=\frac{a(a+b)}{a(a+b)}+\frac{aaa}{a(a+b)}+\frac{b(a+b)}{a(a+b)}$$
$$=\frac{aaa+aa+2ab+bb}{a(a+b)}$$

$$2-\frac{x-1}{x+1}=\frac{x+3}{x+1} \qquad a-x+\frac{aa-ax}{x}=\frac{aa-xx}{x}.$$

What is the *sum* of $\frac{a}{c}+\frac{b}{c}$? *Ans.* $\frac{a+b}{c}$.

Add $\frac{a}{b}+\frac{m}{n}+\frac{x}{y}$. *Ans.* $\frac{any+bmy+bnx}{bny}$.

$$\frac{a}{m}+\frac{b}{m}+\frac{c}{m}=\frac{a+b-c}{m}.$$

$$\frac{a}{m}+\frac{b}{n}+\frac{c}{o}=\frac{ano+bmo+cmn}{mno}.$$

$$\frac{aa}{c}+\frac{bb}{c}=\frac{aa+bb}{c}.$$

$$\frac{a+b}{c}+\frac{2a+d}{c}=\frac{3a+b+d}{c}.$$

$$\frac{a+x}{b}+\frac{c}{2d}=\frac{2ad-2dx+bc}{2bd}.$$

What is the difference of $\frac{a}{c}-\frac{b}{c}=\frac{a-b}{c}$.

$$\frac{a}{b}-\frac{m}{n}=\frac{an-bm}{bn}.$$

$$\frac{a}{c}-\frac{b}{c}=\frac{b-c}{c}.$$

$$\frac{a}{m}-\frac{b}{n}=\frac{bm-an}{mn}.$$

$$\frac{a+b-d}{d+a}-\frac{2b}{d+a}=\frac{a+b-d}{d+a}.$$

$$\frac{3a+b-d}{c}-\frac{2a+d}{c}=\frac{a+b}{c}.$$

$$\frac{9x}{2}-\frac{2x+1}{3}=\frac{23x-2}{6}.$$

ASTRONOMY.—CHAPTER VI.

MARS—PERIOD—COMPRESSION—APPARENT RETROGRADE MOTION—TELESCOPIC APPEARANCE—RUDDY COLOUR—POLAR SNOWS—AXIAL ROTATION—SEASONS—ATMOSPHERE—SATELLITES—MINOR PLANETS—FLORA—CERES—PALLAS—JUNO—VESTA—ECCENTRICITY OF ORBITS—JUPITER—PERIOD—DIAMETER—BELTS—PHYSICAL NATURE—DARK SPOTS—LUMINOUS SPOTS—AXIAL ROTATION—CENTRIFUGAL FORCE AT EQUATOR—BRILLIANCY—FOUR SATELLITES—ECLIPSES OF SATELLITES—OCCULTATIONS—TRANSITS—PECULIARITIES OF SATELLITES IN TRANSIT—VARIATION OF BRILLIANCY—DISCOVERY OF VELOCITY OF LIGHT—MASS OF JUPITER—TABLES OF JUPITER.

THE EXTERIOR PLANETS—MARS, ♂.

THE first planet exterior to the earth in the order of distance from the sun is Mars, and this planet bears a closer analogy to the earth than any of the other planets. Mars revolves round the sun in 686 days 23 hrs. 30 min. 41 sec., at a mean distance of 139,312,000 miles. The eccentricity of its orbit is 0·093, which increases the distance to 152,284,000 miles, or reduces it to 126,340,000 miles. The apparent diameter of Mars varies between 4·1″ in conjunction and 30·4″ in opposition; and owing to the greater eccentricity of the orbit of Mars its apparent diameter, as seen from the earth, will vary considerably at different oppositions. The diameter at mean distance of the planet from the earth, as given by Le Verrier, is 7·28″, and its real diameter is about 4000 miles. The amount of compression is variously stated. Sir W. Herschel gives it at $\frac{1}{16}$; Schröter at less than $\frac{1}{80}$; Arago, after thirty-six years' observation, calculated it at $\frac{1}{30}$; Hind gives it at $\frac{1}{51}$, and Main considers that $\frac{1}{39}$ is not very far from the truth. Mars exhibits phases, but not to the same extent as the inferior planets. In opposition the disc is perfectly circular; between this and the quadratures it is gibbous; and at the minimum phase, which occurs at the quadratures, the planet resembles the moon three days from the full. The character of these phases prove that Mars shines by reflected light from the sun. After conjunction, when Mars first emerges from the sun's rays, it rises some minutes before the sun, and has a direct or easterly motion; but as this motion is only half that of the earth in the same direction, Mars appears to recede from the sun in a *westerly* direction, although its real motion among the stars is towards the east. This continues for nearly a year, and ceases when its angular distance from the sun amounts to $\pm$ 137 degrees; then for a few days it appears stationary. Its motion then becomes retrograde, or westerly among the stars, and continues so until the planet is 180 degrees distant from the sun or in opposition, and consequently on the meridian at midnight; at this period its retrograde motion is swiftest; it afterwards becomes slower, and ceases altogether when the planet is again at a distance of about 137 degrees on the opposite side of the sun. Its motion then again becomes direct, and continues so until the planet is again lost in the solar rays, when the phenomena are repeated, but with a considerable difference in the extent and duration of the movements. The retrograde movement commences or finishes when the planet is at a distance from the sun which varies from 128° 44′ to 146° 37′, the arc described being from 10° 6′ to 19° 35′; the duration of the retrograde motion in the former case is 60 days 8 hrs., and in the latter 80 days 15 hrs. The period in which all these changes take place, or the interval between one conjunction and one opposition, constitutes the synodical period, which amounts to 780 days. Mars and the Earth come *nearly* to the same relative position every twenty-three years, but several centuries pass before exact coincidence occurs. Mars when in opposition is a very conspicuous object in the heavens, shining with a fiery red light. Its *synodic period* being 780 days, it comes to opposition and attains its maximum brilliancy once in rather more than two years. When in perihelion and in perigee at the same time, which occurs once in four synodical revolutions, or about eight years seven months, the planet shines with a brilliancy rivalling that of Jupiter. When observed through a powerful telescope Mars is found to be covered with dusky patches of a dull red hue (Plate VIII., figs. 1, 2, 3), supposed with good reason to be continents analogous to those of our own globe; other portions of a greenish hue are believed to be tracts of water. The red hue which overpowers the green gives the tone to the whole planet. Viewed through the telescope, Mars appears less red than to the naked eye. If these surmises are correct, the proportion of land to water on the Earth is reversed on Mars; on the Earth every continent is an island; on Mars all seas are lakes. From the different distribution of the water, long narrow straits are more frequent than on the Earth. On the Earth the proportion of water to land is about 11 to 4, on Mars the proportions are probably about equal; and the water on Mars is for the most part disposed in long narrow channels. In the vicinity of the poles brilliant white spots have been observed, which are now considered by astronomers to be masses of snow, a supposition which is materially strengthened by the circumstance that they have been observed to diminish when brought under the sun's influence at the commencement of the martial summer, and to again increase on the approach of winter. Sir W. Herschel, who discovered the circumstances attending their variation of size, noticed that they were not always precisely opposite, both being sometimes visible or invisible at the same time. Mädler observed that the south polar spot underwent greater changes of magnitude than the northern one, an observation which harmonizes with the fact that it experiences a greater variety of climate from the eccentricity of the planet's orbit. The northern patch has been found to be concentric with the planet's axis, while the south one is considerably eccentric. Spots seen on the body of Mars early led to attempts to determine its period of axial rotation.

The most recent observations are those of Mädler, who gives the time of revolution at 24 hrs. 37 min. 23 sec. Sir W. Herschel fixes the period of revolution at 24 hrs. 39 min. 21·67 sec., and he assumes that the obliquity of the ecliptic on Mars is about 28° 42′, an angle so close to that which obtains for the Earth as to warrant a belief that the seasons of Mars are not materially different from our own. The Martial year consists of 668 Martial days and 16 hrs., the Martial day being longer than the terrestrial in the proportion of 100 to 97. On account of the eccentricity of the planet's orbit, the summer half of the year in the northern hemisphere consists of 372 days, the winter half being 296 days. In the southern hemisphere the winter half consists of 372 days, and the summer of 296 days. The duration of the seasons in the northern hemisphere are, spring 191, summer 181, autumn 149, and winter 147 days. For the southern hemisphere the seasons are reversed. Thus the spring and summer are seventy-six days longer in the northern hemisphere than in the southern. It is generally admitted

ASTRONOMY.

MARS, JUPITER'S BELTS AND COLOURED STARS.

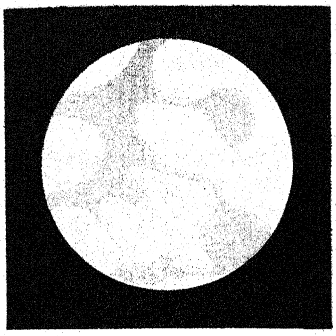


Fig 1.

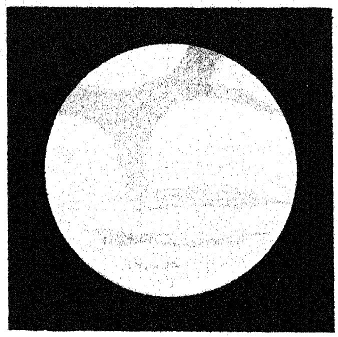


Fig 2

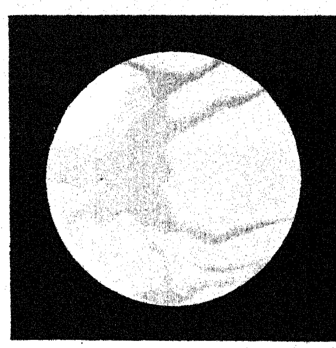


Fig. 3.

Variations in the telescopic appearance of Mars.

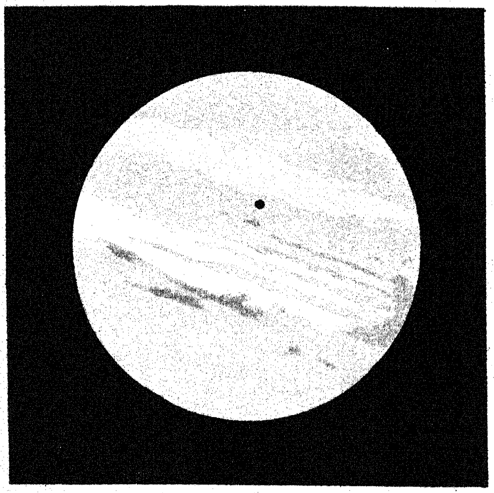


Fig 4.

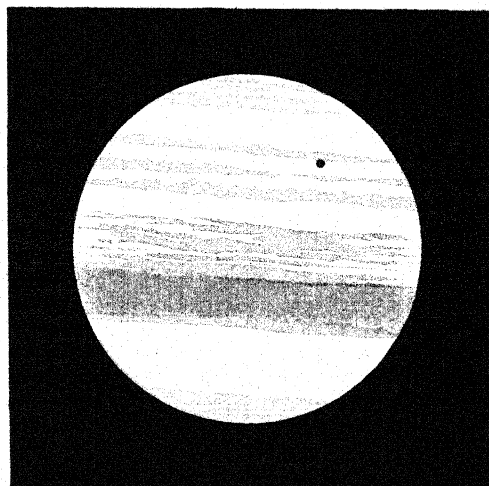


Fig 5.

The Belts of Jupiter.

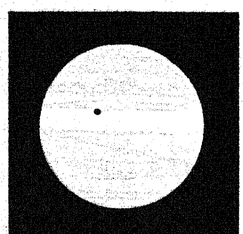


Fig 6.

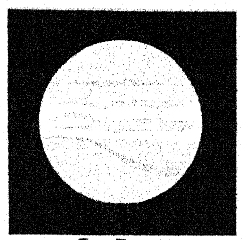


Fig 7.

Oblique Belts of Jupiter.

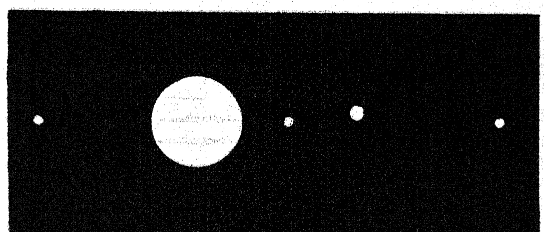


Fig 8.
Jupiter and its Satellites.

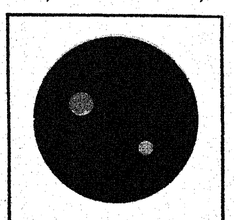


Fig 9.
γ Andromedae.

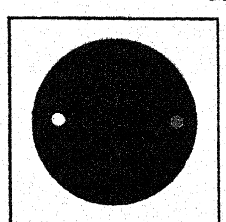


Fig 10.
ρ Leporis

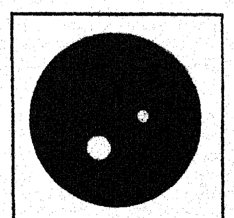


Fig 11.
η Cassiopeiae

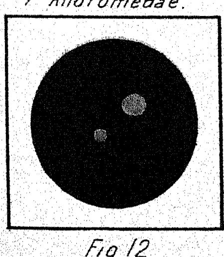


Fig 12
ε Bootis

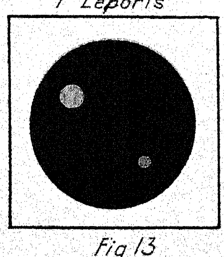


Fig 13
β Cygni

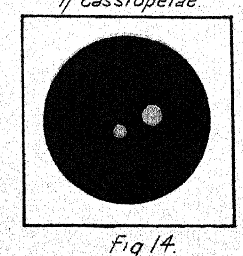


Fig 14.
δ Cassiopeiae

that Mars possesses an atmosphere which is moderately dense. Mars is now ascertained to possess two satellites, the smallest bodies known in the solar system, and invisible to all but the most powerful telescopes. They present no visible discs to measure, and their size can only be approximated from their brightness; they do not exceed 10 miles in diameter. Their distances from the planet are about one and a half and seven diameters, and their periods about eight and thirty hours respectively. The mass of Mars is variously estimated. Burckhardt makes it $\frac{1}{2680337}$ of the sun, Mädler $\frac{1}{2680500}$, and Le Verrier $\frac{1}{2968300}$. In computing the places of Mars, the tables of Le Verrier, published in 1861, are employed.

THE ASTEROIDS.

The researches of late years have led to the discovery of a numerous group of small bodies revolving round the sun in the wide interval that exists between the orbits of Mars and Jupiter. These planets, termed the *minor planets* or *asteroids*, differ in some respects from the other members of the solar system, especially in point of size, the largest being probably not more than 200 or 300 miles in diameter. Their orbits also are much more inclined to the ecliptic than the orbits of the major planets. The nearest to the sun is Flora, which revolves in its orbit in 1193 days, or $3\frac{1}{4}$ years, at a mean distance of 201,274,000 miles. The most distant is Freia, with a period of 2299 days, or 6·3 years, and at a mean distance of 311,713,000 miles.

The least eccentric orbit is that of *Lomia*, in which the eccentricity amounts to no more than 0·023. The most eccentric orbit is that of *Othra*, in which the eccentricity amounts to 0·381. The least inclined orbit is that of Massilia, in which the inclination amounts to 0°41′. The most inclined orbit is that of Pallas, in which the inclination amounts to 34°42′. The brightest, and possibly the largest, of the minor planets is *Vesta*. The more recently discovered planets are all so small that it is difficult to name which is the smallest. Several of the minor planets have been found only to be lost again, and their positions cannot now be determined. Others have been found again after being lost.

Ceres has sometimes been seen with the naked eye, having then the brightness of a star of the seventh magnitude; in general it resembles a star of the eighth magnitude. Its light is somewhat of a reddish tinge, and a haziness round the planet has been attributed to the density and extent of its atmosphere.

Pallas, when nearest the earth in opposition, shines as a full seventh-magnitude star with a yellowish light. Traces of an atmosphere have also been observed. *Juno* shines as an eighth-magnitude star, with a reddish light. *Vesta* appears at times as brilliant as a sixth-magnitude star, and may then be constantly seen with the naked eye. The light of Vesta is usually considered to be white, but Hind considers it a pale yellow tint. Olbers, in determining the elements of the orbit of *Pallas*, remarked the close coincidence existing between the mean distance of that planet and *Ceres*, and it is found that a very intimate connection does apparently exist between these minute bodies, so much so, that if their orbits were figured under the form of material rings, these rings will be found so entangled that it would be possible, by means of one among them taken at hazard, to lift up all the rest. Many of these small planets have been discovered independently by two or more observers. All the brighter planets have evidently been found, and each new planet discovered is fainter than its predecessor, and consequently small telescopes are now incapable of making new discoveries. *Flora*, *Victoria*, *Melpomene*, and *Metis* are the only minor planets for the determination of whose places tables are as yet calculated. The number of the minor planets is frequently enlarged by additional discoveries. On 1st April, 1886, Herr Palisa of Vienna discovered another, of the thirteenth magnitude; and a further addition was made by Dr. Suther of Dusseldorf on 4th May, 1886, of one of the eleventh magnitude (No. 258).

JUPITER, ♃.

The planet Jupiter is the largest of the solar system, revolving round the sun in 4332·6 days, or 11·86 years, at a mean distance of 475,693,000 miles. The eccentricity of its orbit is 0·048, which gives as its greatest distance from the sun 498,603,000 miles, and its nearest approach 452,782,000 miles. Jupiter's apparent diameter varies between 50·7″ in opposition and 30·8″ in conjunction, being 37·91″ at its mean distance. The planet's equatorial diameter is 88·400 miles or thereabouts. The compression at the poles is greater than that of any other planet (Saturn excepted), and amounts, according to the observations of Main, to $\frac{1}{1684}$. Lassell gives the amount at $\frac{1}{1785}$. Jupiter exhibits a slight phase, in quadratures it is gibbous, the illuminated portion always exceeds a semicircle, and owing to the great distance of Jupiter the diminution of light is very small, and only perceptible in the form of a slight shading off of the limb furthest from the sun; this is more readily noticed in twilight than in total darkness. Viewed through the telescope the belts of Jupiter form the principal characteristic. They consist of dusky streaks of varying breadth and number, lying more or less parallel to the planet's equator. It is generally supposed that the planet is enveloped in dense masses of vapour, and that the belts are merely longitudinal fissures in these clouds exposing the more solid mass beneath. These belts, or perhaps atmospheric fissures, are constantly changing their features. Sometimes only two or three broad ones are observed; at other times the planet's disc appears, traversed by as many as eight, ten, or more narrow ones. These appearances are not permanent, but change from time to time, and occasionally with extreme rapidity, even in the course of a few minutes; at other times the alteration is only gradual, and they may retain nearly the same forms for several consecutive months. Commonly they are absent immediately under the equator, but north and south of this line there is generally one wide streak and several narrower ones. The luminosity of the planet at each pole is feebler than elsewhere. The belts are distinguished usually by a grayish tint, the body of the planet being frequently rose-colour; but more powerful telescopes bring out traces of a brownish tinge, especially on the larger belts (Plate VIII., fig. 4). Occasionally, as during the years 1869–72, the belts are characterized by considerable variety of colour—copper, deep purple, claret, red, orange, Roman ochre, being the terms employed by Browning and others to describe the colours. Plate VIII., fig. 5, is from a sketch by Lassell in December, 1871. These colours fade away towards the margin of the disc on either side, a circumstance thought to arise from the fact that the portions of the planet's atmosphere, near the limbs, are necessarily viewed obliquely. Occasionally, but rarely, oblique belts may be seen (figs. 6, 7), and under powerful telescopes various irregularities are observed, which under lower powers are simpler outlines. Spots are occasionally visible on Jupiter's disc. A remarkable spot was observed by Airy between December 11, 1834, and March 19, 1835, and during a portion of this interval a second was seen. In 1843 a very large black spot was noticed, and in November and December, 1858, two oblong dark spots were observed. *Luminous* spots have also been noticed, sometimes singly, and at other times in clusters. In October 25, 1857, no fewer than eleven were seen all clustered together in the southern hemisphere. Nothing is known of the physical nature of either the dark or the luminous spots; but recent observations indicate that the large white patches on the equatorial zone of Jupiter *cast shadows*, an indication that these patches project above the general surface of the planet. All the appearances presented seem to point to the conclusion that the actual body of the planet is not seen either in the dark belts or the bright ones. The general form of the spots of both kinds is more or less that of a circle. Cassini, by close observation of the spot he observed in July, 1665, detected movement, and by its means calculated a period of axial rotation of about 9 hrs. 56 min. The observations of Airy and Mädler, in 1835, give 9 hrs. 55 min. 21·3 secs. and 9 hrs. 55 min. 29·9 secs. The axial rotation of Jupiter's mass being so much more rapid than that of the Earth, combined with its greater diameter, results in the motion at its equator having a higher velocity than that of any other planet, being 466 miles per minute, as against the Earth's 17 miles per minute,

consequently the intensity of the centrifugal force must be very great, and the polar compression proportionally large.

Under favourable circumstances Jupiter, like Mars, rivals Venus in brilliancy, and casts a shadow. Bond found that for photographic purposes its surface reflects light better than that of the Moon in the ratio of 14 to 1. Zöllner calculates that Jupiter reflects 0·62 of the light it receives, the Moon reflecting only 0·17 of the incident light. With Jupiter strong indications exist of inherent luminosity; and various circumstances point to the conclusion that this planet is itself a miniature sun. The heat derived from the sun is comparatively so small that it would leave water on Jupiter's surface about 260° C. below freezing point. Any clouds, therefore, must arise from internal heat. Again, if it is conceived that the Earth and Jupiter were simultaneously formed, Jupiter would retain its heat for ages after the Earth had cooled down.

Seen from the Earth, the apparent motion of Jupiter is sometimes retrograde. The length of the arc of retrogradation varies from 9° 51′ to 9° 59′, and the time of its performance from 116 days 18 hrs. to 122 days 15 hrs. This retrograde motion commences or ends when the planet is at a distance from the Sun which varies from 113° 35′ to 116° 42′. Jupiter possesses four satellites, first seen by Galileo at Padua, January 7, 1610. They shine with the brilliancy of stars of the sixth or seventh magnitude, but from their proximity to the planet are generally invisible to the naked eye. Fig. 8, Plate VIII., gives the general appearance of Jupiter and the four moons, viewed through a telescope of moderate power. The satellites of Jupiter are distinguished by ordinal numbers. The first satellite is the one nearest the planet, the fourth the one furthest removed. The third is the largest and brightest, and can usually be identified with little difficulty. The eclipses, occultations, and transits of Jupiter's satellites afford an endless series of interesting and useful phenomena. The first, second, and third satellites, in consequence of the smallness of the inclinations of their orbits, undergo once in every revolution an eclipse in the shadow cast by the planet into space. The fourth, from its orbit being more inclined and its distance from the planet considerable, does not become eclipsed nearly so frequently. When the satellites enter the shadow the *immersion* is said to take place; when they come out of it, the *emersion*. Associated with the eclipses are the occultations, that is, when the satellite is hid by the direct interposition of the planet itself, independently of the shadow. When the planet has passed its conjunction with the sun, the shadow is projected on the western side, and at this time both the immersions and emersions of the third and fourth satellites may be observed, but not always those of the second; and only the emersions of the first, in consequence of its proximity to the planet causing it to enter the shadow behind the planet. When Jupiter is near its opposition to the sun, the immersions and emersions take place very close to the planet's limbs. As the planet again approaches conjunction the shadow is projected on the eastern side, giving rise to phenomena partly complementary to those described.

The transits of the satellites and their shadows across the planet are of frequent occurrence when the satellites are in those parts of their respective orbits which lie nearest to the earth. The satellites appear on the disc of the planet as round luminous spots preceded or followed by their shadows, which show themselves as round blackish spots. The shadow precedes the satellite when Jupiter is passing from conjunction to opposition, but follows it when the primary is between opposition and conjunction. When actually in conjunction the shadow is in a right line with the satellite, and the two may be superposed. Some peculiarities in the appearance of the satellites during transit are well attested. III. is nearly always seen almost as dark as its shadow. IV. has recently been often so seen. II. has never had the slightest shading on its disc, and I. only a gray tinge. Jupiter's satellites move in orbits nearly circular, and between the motions of the first three a singular relation exists:—The mean sidereal motion of I., added to twice that of III., is constantly equal to three times that of II.; so that the sidereal longitude of I., plus twice that of III., minus three times that of II., yields a remainder always constant, and in fact equal to 180°.

	Sidereal Motion per Second of Time.	
Satellite I.,	$8·478706 \times 1 = 8·478706$	a.
" II.,	$4·223947 \times 3 = 12·671841$	b.
" III.,	$2·096567 \times 2 = 4·193134$	c.
" IV.,	0·898795.	

Adding a and c together $=12·671840$, which quantity is to five places of decimals the same as b. From this it follows that for an immense period of time the three satellites cannot all be eclipsed at the same time. It occasionally, but very rarely, happens that all four satellites are for a short time invisible, being either directly in front or behind the planet. This curious phenomenon occurred on August 21, 1867, when the planet appeared without satellites for one hour and three quarters. The satellites appear to vary in brilliancy from some cause at present undetermined. It was to observations of the satellites of Jupiter that we owe the discovery that light is not propagated instantaneously through space. [See "Light," NATURAL PHILOSOPHY.] It was observed that the calculated times of the eclipses did not correspond with the observed time, and that the difference was a quantity constantly affected by opposite signs of error according as Jupiter was in perigee or apogee. In the former case the eclipse always occurred before the calculated time, in the latter always after it. The regularity with which these anomalies presented themselves gave rise to the suspicion that they had their origin in the variations which occurred in the distance of Jupiter from the earth; that as this distance increased or diminished, so a longer or a shorter period was necessary for light to traverse the space between the two planets.

The mass of Jupiter has been very accurately determined. Laplace, from observations of the fourth satellite, placed it at $\frac{1}{1067}$; Bouvard, from the perturbations of Saturn, at $\frac{1}{1070}$; Nicolai, from the perturbations of Juno, at $\frac{1}{1053·92}$; Encke, from the perturbations of Vesta, at $\frac{1}{1050}$; and from the perturbations of the comet bearing his name, at $\frac{1}{1054}$; Krüger, from observations of Themis, at $\frac{1}{1047·54}$; Jacob, from the motions of the satellites, at $\frac{1}{1047·54}$; and Möller, from the motions of Faye's comet, at $\frac{1}{1047·78}$. Any one of these last three values may be considered substantially exact. The tables of Jupiter used are Le Verrier's; and for the satellites Damoiseau's tables, published in 1836, are employed.

PENMANSHIP.—CHAPTER V.

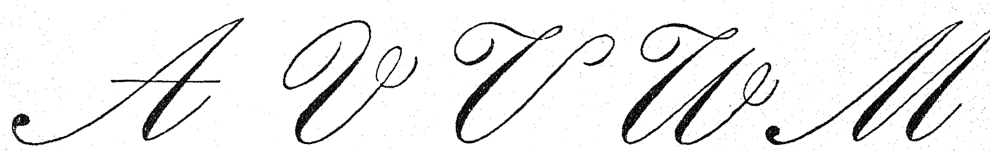
CAPITALS—THEIR CLASSIFICATIONS, FORMS, &c.

PENMANSHIP does not consist in the mere formation of certain conventionally intelligible marks upon paper. It implies the fixed habit—only attainable by constant and careful practice—of forming correct and well-shaped written characters. Though writing is, for the most part, regarded as a mere mechanical acquisition, easily attainable by any one who will devote himself with thorough engrossment to the production of close and perfect imitations of excellent models, wisely chosen, yet, we believe, it is capable of being pursued in a scientific manner, upon correct principles, following an intelligible classification, and resulting in a good scheme of well-arranged studies. The laws of form and the requirements of shapeliness may be understood and applied as aids and helps to the efforts of mere imitation. In the hope of accomplishing something for the intellectual guidance of the penman we have prepared on Plate II., in two specimen alphabets, classified forms of capitals, which we should like to explain and to recommend as the foundation of the practical exercises in penmanship through which a free, easy, and legible style of handwriting may be intelligibly acquired by those who patiently and painstakingly proceed to work for the attainment of an exact and useful system of caligraphy.

The student who desires to begin in the easiest manner to make capital letters should perhaps examine and endeavour

to understand the mode of forming the second row of the upper capital series of letters presented on Plate II., that is, those letters which are arranged under the heading "straight line." It will be readily observed that the first member of that series, X, is very simply formed, consisting as it does in reality of what used to be called "a pot-hook" and "a hanger" joined together by a slight hair-stroke ligature, an element with which, however, the writer may dispense if he so pleases. The main elements employed may be described as (1) a right upward curve turning round gradually to meet (2) a downward sloping line; then, without lifting the hand, let the pen pass upwards within the line so formed half-way, after which cause the pen to make (3) a hair-stroke slightly slanting towards the right and rising to the height of the curve; on this hair-stroke carry down (4) a heavy downward main-slant line for nearly three-fourths of the length of the letter, at which point begin to thin gradually so as to form (5) the under left-hand fourth of an oval. This might perhaps be more concisely and quite as intelligibly described by saying:—Form first the one half of the small-hand letter *n* (text-size), and to this add the latter half of the letter *u*. The next letter, H, is nearly equally simple. It is formed by (1) a connective slant hair-line, beginning about one-third of the (intended) size of the letter; (2) a full length heavy slanting down-stroke; (3) a similar stroke repeated at a distance equal to one-third of the height of the capital, from the lower part of which, about one-fifth up, and turned towards the left, sufficiently rounded to pass beyond the first straight line, let there spring out (4) a connective oval as shown in specimen 4, mid-line of Plate II. The first part of K resembles that of H. We next have a terminal element, like example 1 in the upper line of the middle section of the Plate, a medial connective like example 1 in the middle line, and the lower fourth of an oval. The letters P, B, and R have each the same first element as H and K; besides this the first has an inverted oval springing out from the right of the main-slant, and swirling round to the right of that line; the second has this oval doubled, with the latter generally somewhat larger than the former; the third has the upper oval like P, with the medial connective and terminal lower fourth of an oval similar to K. The elements of similarity in these six capitals are easily noted, and whenever we have learned to manage that element fairly in one, we have got so far towards the accomplishment of it in all the others.

We now proceed to take up the configuration of the first line on Plate II., brought together in this classification as "angular letters," that is, capitals in which the angle prevails, and of which its occurrence forms a feature. Probably the best way to approach the study of these letters is to examine them closely. In doing so the student will be likely to see at once that, in reality, the form of V is really repeated twice in W, and that it forms the latter two-thirds of N. Again, we perceive that the first elements in A, N, and M are alike, and that in fact, comparatively speaking, just as W presents us with a double form of V, the capital M gives us a duplex of A. Taking A, N, and M, we have a lower initial dotted oval joined to an upwardly slanting grace-line, to the top of which, with an acute angle, the last element in H is joined. To the upward slanting grace-line seen in A the capital N adds the form of V. This V itself is a simple form, consisting of the first element in H, only that it is, to give greater pleasantness to its appearance, slightly tapered towards the ends. From the foot, making an acute angle with it, the grace-line which is seen in A rises, and the dotted oval with which it terminates exactly resembles that with which A commences reversed. Indeed, so far as the main elements of V are concerned, they might be described as those of A reversed. Tracing thus the similarities of the elementary forms of these capitals, we can see at once that each part over which we acquire mastery makes the effort required to accomplish the next less difficult. The terminal oval of M may be in practice—when it is used in the writing of a word—omitted, and the turn given to it then is just like that of a small-hand *n*. Some people prefer rounded corners to the sharp angles here given, and to this there can be no real objection offered, although it is found rather difficult to make the curving of the angular part take such a grace as one likes to see in capital letters. It is not unusual to give the A a terminal oval turn similar to that seen in M, and to draw a horizontal line through the letter about one-third its height. Instead of the form given in the Plate, these letters then assume some such shape as is given below.



The third line on Plate II. comprises those capitals in which the "grace-line" forms the chief special element. The main down-line in each of these letters, as may be seen at a glance, is the Hogarthian one. Beginning slightly above the middle of the (intended) capital, with a portion of an elliptical oval taking its curvilinear sweep towards the left, we next produce a down-slope grace-line, and add (as in the Plate) a dotted ovalesque terminal. The next capital consists of (1) a horizontal grace-line, lying across the top and joined by a curved hook to (2) a similar grace-stem to that which appears in I. Precisely the same form occurs in F, but across the centre of the grace-stem there is placed a curvilinear hook and loop exactly similar to the union-loop of the two grace-lines at the top of the letter. The underlying half of an elliptical oval, drawn horizontally, forms the first element of S; the second is the same grace-stem as is used in the three previous letters. An L is formed in every essential particular like an S until the grace-stem ends; then, instead of adding on the terminal oval, we draw a horizontal grace-line from the terminal point of that line, and recrossing it on the level base-line of the writing. The grace-stem element of the L, together with the horizontal grace-line crossing it, reappear in D; but to form its back there is required the right side of a vertically drawn oval, into the formation of which the level grace-line merges, and to the curving top of which there falls to be added a full free oval, like an O produced with the incidence of the connective slant. One of the chief difficulties felt in forming L and D is the making of the union-loop between the two grace-lines on the left of these letters. In doing this, the end of the grace-stem requires to be carried up till it has just reached the point of retroversion or turning backward; at this precise point the horizontal grace-line should take its origin, and should be, from that, so curved, that at one-half of its length its lowering inclination should begin, and so soon as this line has reached the base of the general writing its upward curving should be made. Unless great care is taken in this particular part a disagreeable angularity and failure of grace occurs, and in the case of D leads to the upward sweep of the hand in the manipulation of the left semi-oval being awkwardly caught, so that a humphy angularized appearance is presented at the union point of that semi-oval and the full oval which curves round on the left of the upper half of the grace stem. A capital J is formed of the upper two-thirds of an I together with the form of the small letter *j*, or the tail (as it is called) of a capital Y joined to it. Three grace-lines, one horizontal, somewhat to the left and looped as in T and F, one light down-slanting for the central grace-stem, and another horizontal one looped and crossing the main-line, as in L and D, towards the right, constitute Z.

The "circular" or curvilinear group occupies the fourth class. The first is an oval O, formed exactly as the small-hand letter is. Beginning at the top, a full left-curved line is made with a gradual shade, growing heavier till the curved turn reaches

the middle; giving a broad rounded turn at the base we make a right upward curve similar to that on the other side, and at about an eighth less than the whole length of the letter, bring the top turn broadly round at a little distance from the first curved line, to which the closing one should be kept nearly parallel about half-way down. In writing C we begin with the first oval sweep of S and L, form a left side curve like that of an O, and when the broad round turn of the base of the oval has been made, sweep suddenly round so as to make five-eighths of a small oval. In G a sweep similar to that which constitutes C (only two-thirds of the size, however) is used, but the base-oval is suddenly arrested, and the lower third of the letter I is attached to it on the right-hand side. An E consists of two ovals; the upper and smaller is about half the size of the lower, which, besides being twice the size, takes the form of the lower oval portion of C. The letter Q takes the form of figure *2*. It is an inverted oval of the type used in C with the lower left loop of L added to it. In U the first ovalesque form is similar to that used in Q; instead, however, of curving concavely towards the left, the lower half of the oval of O is added to it, and to the up-curve on the right of this a small-hand *l* form is attached. The first portion of Y is similar to Q (only two-thirds, however, of the size), and to this a small-hand *j*, or the latter half of a capital J-form, is attached.

In this way, making use of classification and analysis, we can gather together resembling forms and bring before our minds similar parts. This enables us to see how the same skill as has been attained in former efforts is again demanded in the forming of new compounds, and every gain we make we know is giving us fitness for succeeding in our next endeavour. Instead of regarding each individual letter as a separate integral form to be studied and produced, we perceive that they are compounds made up of simpler elements, and know that when we have mastered these elements we have only the work of combination to achieve, and then we shall possess the power of using skilfully and intelligently the art and mystery of penmanship. We shall explain similarly the "flowing grace-line capitals," given in the lower half of Plate II., in our next lesson.

NATURAL PHILOSOPHY.—CHAPTER XI.

WATER COURSES — VELOCITY OF STREAM — OPENINGS OF BRIDGES—MILL STREAM AND WATER WHEELS—TURBINES —WATER MOTORS—WATER-RAISING MACHINES—RESISTANCE OF BODIES MOVING IN WATER—CAPILLARY ATTRACTION —ATTRACTION OF FLOATING BALLS—SPHERICAL FORM OF DROPS—SURFACE TENSION—DIFFUSION OF LIQUIDS—CRYSTALLOIDS—COLLOIDS—ENDOSMOSE—EXOSMOSE.

If the flow of a body of water in a river or large open water-course experienced no resistance from the friction of the banks and the bed of the stream, its motion would go on continually accelerating from its source to its mouth, like that of a solid body falling by the action of gravity; and the consequences would be, that besides the destruction resulting from the impetus of the torrents in the lower levels, the entire land of the higher elevations would be drained of all moisture, so that the soils would become sterile and incapable of growing crops or sustaining vegetable and animal life. The adherence of the particles of water to each other, and the friction of the water in moving against the beds, produces a resistance which increases with the velocity of the current, and this resistance becomes at length equal to the accelerative force of the descent; and then a uniform motion of the stream is established. But when a current is in a state of equilibrium, the velocities in different transverse sections of the river may be very unequal, on account of the variations in the areas of those sections, through all of which the same quantity of water must flow in the same time; if this were not so the equilibrium of the river would be destroyed. From this it follows that the products of the areas of the sections multiplied by the velocities in each must be equal to each other, and that the velocities in different sections must be inversely proportional to the areas of those sections. The velocity, however, varies in the section, being a maximum at the surface and where the channel is deepest, which is usually near the centre of the width, diminishing from that point to the banks on either side, and to the bottom, where it is a minimum. The mean velocity of water in a river may be expressed approximately by the formula $307\sqrt{\frac{r}{l}}$, in which r, usually denominated the mean radius, is in inches the quotient of a division of the area of a transverse section of the river by the breadth, the latter being measured on the surface of the bed; and l is in inches the distance of a portion of the river between two points in its length, whose difference of level is one inch. By experiment it has been found that, if v' = the velocity at the surface of the river, v'' the velocity at the bottom, and v the mean velocity as above, all being expressed in inches per second, then $v''=(\sqrt{v'}-1)^2$, and $v=\frac{1}{2}(v'+v'')$. The best experiments give the mean velocity throughout the section at 84 per cent. of the maximum central surface velocity, which is generally the velocity observed. The following table gives the mean velocity corresponding to observed maximum velocities:—

MEAN VELOCITY FOR OPEN CHANNELS, CANALS, AND RIVERS, FROM OBSERVED CENTRAL SURFACE VELOCITY.

Surface Veloc.	Mean Velocity.	Surface Veloc.	Mean Velocity.	Surface Veloc.	Mean Velocity.	Surface Veloc.	Mean Velocity.
1	·84	26	21·84	51	42·84	76	63·84
2	1·68	27	22·68	52	43·68	77	64·68
3	2·52	28	23·52	53	44·52	78	65·52
4	3·36	29	24·36	54	45·36	79	66·36
5	4·2	30	25·2	55	46·20	80	67·2
6	5·04	31	26·06	56	47·04	81	68·04
7	5·88	32	26·88	57	47·88	82	68·88
8	6·72	33	27·72	58	48·72	83	69·72
9	7·56	34	28·56	59	49·56	84	70·56
10	8·4	35	29·4	60	50·4	85	71·40
11	9·24	36	30·24	61	51·24	86	72·24
12	10·08	37	31·08	62	52·12	87	73·08
13	10·92	38	31·92	63	52·92	88	73·92
14	11·76	39	32·76	64	53·76	89	74·76
15	12·60	40	33·6	65	54·6	90	75·6
16	13·44	41	34·44	66	55·44	91	76·44
17	14·28	42	35·28	67	56·28	92	77·28
18	15·12	43	36·12	68	57·12	93	78·12
19	15·96	44	36·96	69	57·96	94	78·96
20	16·8	45	37·8	70	58·8	95	79·80
21	17·64	46	38·64	71	59·68	96	80·64
22	18·48	47	39·48	72	60·48	97	81·48
23	19·32	48	40·32	73	61·32	98	82·32
24	20·16	49	41·16	74	62·16	99	83·16
25	21·0	50	42·0	75	63·00	100	84·00

Thus, if a channel or canal, whose area is 24 square feet, has a central surface velocity of 35 feet per minute, the mean velocity is 29·4 feet, and the discharge will be $29{\cdot}4 \times 24 = 705{\cdot}6$ cubic feet, or $705{\cdot}6 \times 6{\cdot}23 = 4396$ gallons per minute. A simple method to find the velocity of a stream is to stretch two lines across the stream near to the surface, and about 66 feet apart, and a float being placed a few yards above the highest one, and in the centre of the stream, or where the velocity is observed to be greatest, the exact time of the float passing from line to line is carefully noted. The float should consist of a small piece of *thin* wood, about $\frac{1}{4}$ inch thick, so as to be wholly immersed, and exposed as little as possible to the action of the wind. Assume that the float passes over the 66 feet in 20 seconds, in one minute therefore it would be $\frac{66 \times 60}{20}$ or 198 feet. This being the maximum velocity, the mean over the whole area would be $198 \times {\cdot}84$ or 166 feet per minute, and therefore the discharge is $166 \times 27{\cdot}74 = 4600$ cubic feet per minute.

The mean velocity in any one section may be practically found, with sufficient accuracy, by placing in the stream a rod of wood loaded at one end with a weight sufficient to allow it to float upright in still water. The greater velocity at the upper surface will make the rod incline towards the direction of the stream; and consequently, when it has ac-

HYDRODYNAMICS—WATER WHEELS

Fig. 1.

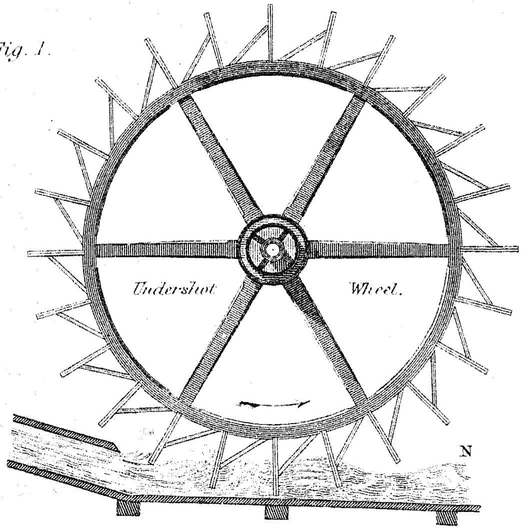


Fig. 2.

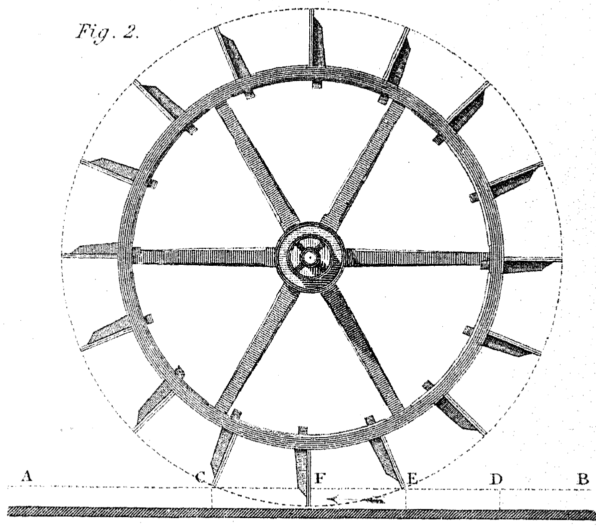


Fig. 3.

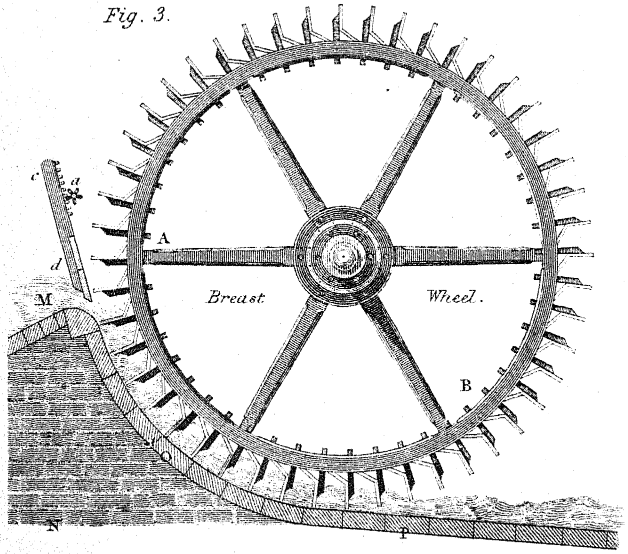


Fig. 4.

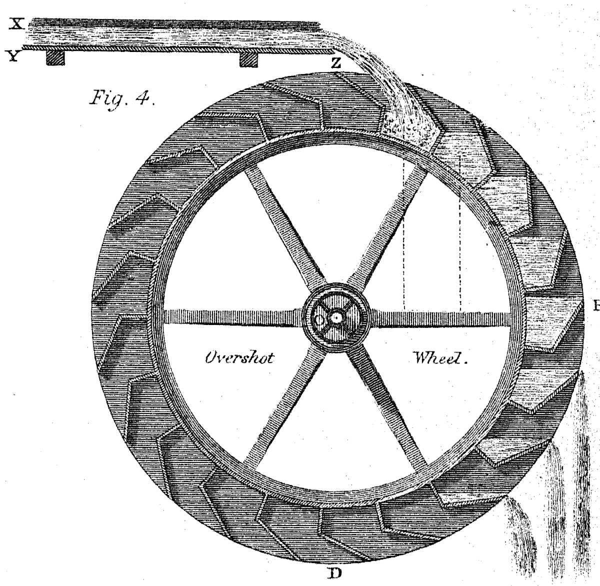


Fig. 5.

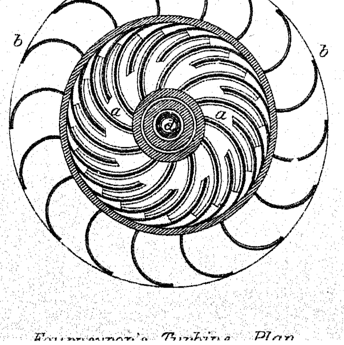
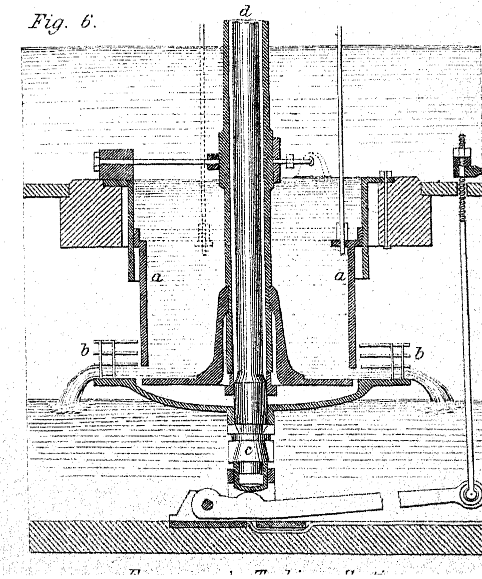


Fig. 6.



Fourneyron's Turbine. Plan

quired a state of equilibrium, it will float in an oblique position; the top of the rod will move slower than the water at the upper surface of the river, and the bottom will move faster than the water in the lower part. Hence, the mean velocity of the water in that part of the breadth of the river may be considered as nearly equal to the observed velocity of the rod. A knowledge of the velocity of the water at the bottom of a river is of considerable value in enabling an opinion to be formed of the action of the stream on its bed; and it is evident that to insure permanency, the accelerative force of the water should be in equilibrium with the tenacity of the channel. The action of a current with a velocity of 3 inches per second at the bottom will remove fine potter's clay; a velocity of 6 inches will lift fine sand; that of 12 inches will sweep away small gravel; 24 inches will roll away rounded pebbles; and 3 feet per second will carry along angular stones of the size of an egg. In the Stronsa Frith and other tideways of the Orkney and Shetland Isles, where the velocity at spring tides exceeds 21 feet per second, boulder rocks of many tons weight are swept before the current.

The head lost by a stream in passing through a bridge is chiefly that due to velocity alone; the length of the channel is generally so short that it has little influence on the discharge. The velocity of discharge through a culvert or submerged opening is dependent upon the *difference* of the level of water at the two extremities of the opening, and is not affected by the depth below the surface at which it is placed. For very short culverts allowance must be made for the velocity at entry. As an example of the practical value of the data given, let it be supposed that it is desired to utilize a stream of water for driving a corn mill. Let the stream be 1500 yards long, with a total fall of 6 feet 6 inches from the tail of the preceding mill. To ascertain the quantity of water available, a spot should be selected in the stream where the current appears to be tolerably uniform for some 100 feet or more, and at a time when the stream is at its average flow. Let the point where this uniformity of current is selected be assumed to be 24 feet wide. To obtain the area of the stream, divide the width into, say, eight equal portions of 3 feet each by stretching a tape across the stream, and then measuring the depths midway between each of the divisions, using a rod with a flat board some 7 or 8 inches square at the end of it, to prevent penetrating the soft bed of the stream; taking the mean of these measurements to be 1·156 foot, the sectional area will be $1{\cdot}156 \times 24 = 27{\cdot}74$ square feet. The velocity of the stream is then found by the method given; the maximum velocity is 66 feet in 20 seconds, so that the mean velocity over the whole area will be $198 \times {\cdot}84$, or 166 feet per minute, and the discharge will be $166 \times 27{\cdot}74$, or 4600 cubic feet per minute. The total fall of the stream is 6 feet 6 inches; and allowing 6 inches for the fall of the stream itself, the net fall at the water-wheel will be 6 feet, a cubic foot of water weighing 62·3 pounds, the horse-power being 33,000 foot-pounds; and allowing that a breast water-wheel utilizes 50 per cent., or ·5 of the gross power of the water, then $\frac{4600 \times 62{\cdot}3 \times 6 \times {\cdot}5}{33{,}000} = 26$ horse-power. Then, as a pair of 4 feet stones, grinding 4 bushels of corn per hour, requires about 4 horse-power, and a dressing machine about 6 horse, and if four pairs of stones are employed, they will absorb 16+6 or 22 horse-power, allowing a surplus of 4 horse-power for the mill-gearing and smaller machinery. The diameter of the water-wheel should be about 2·5 times the fall, say 15 feet, and the speed of its circumference being 4 feet per second, or 240 feet per minute, and with a depth of bucket 1·5 foot, the width of the wheel would be $\frac{4600}{240 + 1{\cdot}5} =$ 12·8 feet, or about 13 feet.

WATER-WHEELS.

In the example given a breast-wheel has been mentioned, but there are various other forms of water-wheels employed to utilize the motive power of water. A water wheel is a wheel provided with buckets or float-boards at the circumference, on which the water acts either by pressure or impact. Figs. 1, 2, 3, 4, Plate VIII., show various forms of water-wheels. Figs. 1 and 2 represent the *undershot* wheel, in which the float boards are either placed radially—that is, at right angles to the circumference of the wheel, as here shown—or at an angle. The lowest float-boards are immersed in the water, which flows with a velocity depending upon the height of the fall. Such wheels are used where the quantity of water is great, but the fall inconsiderable. The total theoretical effect of a fall of water is never realized; for the water, after acting on the wheel, still retains some velocity, and therefore does not impart the whole of its velocity to the wheel. In many cases water will flow past without acting upon the wheel at all. When the water acts by impact, vibrations are set up which are transmitted to the earth and lost. The same effect is produced by the friction of a body of water falling over an edge, A B, of a sluice (fig. 6, Plate X.), in the channel which conveys it, or against the wheel itself, as well as by the friction of the wheel and axle. In the undershot wheel the water acts only by its impulse. The work performed by this form of wheel is from 27 to 30 per cent. In the *breast-wheel* (fig. 3) the flow of water is regulated by the sluice, *c d*, and the rack and pinion, *a*. The head is M N, and the incline for the fall is shown at O P. The percentage of power of the breast-wheel is from 45 to 60 per cent. The *overshot* wheel (fig. 4) is generally employed when the quantity of water is small and the fall considerable, as with mountain streams. On the circumference of the wheel are placed buckets of a form to retain the water during a certain portion of the revolution. The water falls into these buckets on the upper part of the wheel, from the sluice X Y Z, and the wheel is moved forward by the weight of the water. As the wheel revolves the buckets empty themselves, and at the lowest point, D, commence to ascend again empty; the full force of the water in the bucket is exerted when it is at B, as then the leverage is the greatest. Fig. 4 shows the value of the leverage of the buckets in their descent, through the semi-revolution of the wheel.

A *horizontal* water-wheel differs in no respect from an *undershot*, except in its being placed horizontally instead of vertically, and the floats inclined so as to be struck at right angles by the water. Horizontal water-wheels, however, are no longer used, having developed into the *turbine*, a horizontal wheel which is generally entirely submerged at the base of the column of water supplying it, though some varieties act equally well in any part of the column, provided their escape pipe is entirely filled by the falling water. One form of turbine (Fourneyron's) is shown in plan and section in figs. 5 and 6, Plate VIII. It consists of a fixed central cylinder, *a a*, which forms the inlet pipe. It is closed at the bottom, but has an annular opening extending round its entire circumference by which the water can escape laterally, its direction being governed by a series of curved partitions or guides shown in the plan. The wheel, *b b*, surrounds this opening, turning on the pivot, *c*, below. Its buckets consist of a series of partitions curved in the reverse direction to the guides, so as to catch the water as it leaves the latter. After setting the wheel in motion the water makes its escape by the openings in its circumference in a direction at right angles to its axis. This turbine is frequently worked under the surface of the escaping water, in order to utilize the entire available fall, and it has a contrivance by which the amount of water used can be adjusted to the power required of the turbine. This consists of a sliding portion of the cylinder, *a a*, which can be raised or lowered from above, thus increasing or diminishing the aperture by which water is supplied to the wheel, *b b*. The vertical axis, *d*, rises through a tube in the cylinder, and communicates the motion of the wheel to suitable gearing. In other forms of turbine the central wheel is the portion which revolves, the external fixed one merely serving to increase the reaction of the escaping water, while in others the water is supplied to the wheel at the circumference, or at the upper side.

The turbine is considered the most economical form of prime motor yet devised, as it has been made to utilize from 75 to 88 per cent. of the power of the falling water, while, on account of the great speed at which they run, they are

much smaller than water-wheels in proportion to their power. They are much more efficient motors than steam engines, the best of which do not utilize more than 25 to 30 per cent. of the energy represented by the coal they burn.

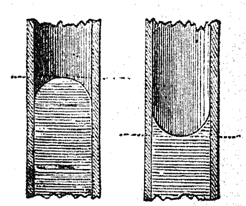
Various experiments have been made upon the percussion of fluids with a view to ascertaining the impact from different heights and under various heads of pressure. The apparatus with which M. Bossut carried out his experiments is shown in fig. 1, Plate IX. The beam, A B, working on the centre, *o*, was 3 feet 6 inches in length; at one extremity was fixed a plate of copper, A, and at the other a scale, S. The water was delivered upon the copper plate from the adjutage, *p q*, fixed in the bottom of the reservoir, V X Y Z. Various forms of machines for raising water are shown in figs. 2 and 3, Plate IX., and 1, 2, 3, 4, 5, Plate X. The Persian water-raising wheel (fig. 2, Plate IX.) consists of a series of buckets, *a a a*, attached to one side of the wheel, C D E F, and hung on pivots, *b b b*, so that by gravity they keep a vertical position during the revolution of the wheel. A catch, *r*, attached to each bucket tilts them successively over on reaching the upper part of the wheel, when the contents are discharged into the trough, *n* M, the buckets regaining their vertical position in the descent. Motion is given to the wheel by the floats fixed on the opposite side, and acted upon by the stream, A B. A pump for raising water by the friction of an endless rope in rapid motion is shown in fig. 3, Plate IX., the water being thrown off from the wheel by centrifugal force. Fig. 4 gives a form of self-acting water motor called the hydraulic pendulum, producing an intermittent oscillating motion. The two water pans, A C and C B, are attached to the arms of a lever working upon a central pivot. On the pan C B receiving a sufficient amount of water from the reservoir, M, to destroy the equilibrium, it descends to the level of the block stop, when it discharges its water, and remains in that position until the pan A C, in like manner by excess of weight, descends, and the pan C B is again in position. Two forms of screw pumps or lifts, the invention of which is attributed to Archimedes, are shown in figs. 1 and 2, Plate X., in one of which the screw, in the form of a spiral, revolves, the water entering at the lower orifice; in the other, shown in section, a central screw-shaft revolves in the interior of an inclined cylinder. In each case the principle is that of raising the water by a series of endless inclined planes step by step as the revolution of the axle forces the water up one thread of the screw. Fig. 3, Plate X., is another form of revolving pump (Wirtz Machine), invented by Wirtz, of Zurich. Here a large spoon or opening of the spiral takes in about equal quantities of air and water alternately, and the elasticity of the bodies of air which thus divide masses of water in the spiral, intensified by the compression occasioned by the latter, powerfully assists the onward passage of the water. The power used to turn the spiral first compresses the air which it contains, and the latter on expanding again drives forward the water. The chain bucket pump is shown in figs. 4 and 5, Plate X. The buckets, *s s s*, are carried round by the upper wheel, delivering their contents into a trough. This form of bucket lift is extensively employed in the construction of dredging machines for deepening harbours, the channels of rivers, and removal of sandbanks, &c.

The resistances experienced by bodies of various forms and lengths when moving in water have formed the subject of numerous experiments carried out by Colonel Beaufoy. The following are some of the more important results :—

The friction of bodies moving in water is equal to a power of the velocity whose exponent is 1·949. The pressure at the head-end varies in rather a higher ratio than the square of the velocity, when the velocity is small, and the exponent diminishes with an increase of velocity. The diminution of pressure on the stern of a vessel caused by the fluid not pressing so strongly there when it is in motion as when at rest, varies in a lower degree than the square of the velocity; and the exponent diminishes with an increase of velocity. A globe experiences about one-third of the resistance which is encountered by a cylinder. A globe cut in halves, and these separated by the intervention of a cylinder whose base and length are each equal to a diameter of the former, experiences a diminution of resistance which, compared with that of a complete globe, is nearly equal to one-fifth of the latter. Bodies whose head-ends are formed with curved lines have great advantage in respect of resistance over those formed with straight lines. The greatest breadth of a moving body should be at a distance from the head extremity equal to two-fifths of the body's length, that the body may move through the water with the least resistance. Increasing the length of a solid of almost any form by the addition of a cylinder in the middle greatly diminishes the resistance with which it moves, provided the weight in water continues to be the same. By comparing the resistance of bodies near the surface with those having similar head and stern ends, and which were immersed to the depth of 6 feet, those at the surface were found to experience more retardation than the others.

CAPILLARY ATTRACTION.

The mutual attraction of the molecules of liquids for each other, and the attraction between these molecules and solid bodies, give rise to the phenomena of *capillary attraction*. The elevation of the general surface of a liquid where it is in contact with the containing vessel, the form of a drop of liquid suspended at the under side of a solid, the rise of oil up a lamp wick, the absorption of water into the pores of a cloth, the employment of blotting paper or the use of a towel for wiping any damp surface, are all instances of capillary attraction. When a glass rod is immersed in water, which adheres to and wets the rod, the surface of the water is raised up against the sides of the rod, and assumes a slightly concave form; but if the rod is dipped into mercury, which does not adhere to the glass, the mercury is depressed against the sides of the rod, and its surface assumes a convex shape. This depression or elevation of the surface of a fluid is more defined when a tube of small diameter is placed in a liquid. According as the tubes are or are not moistened by the liquid an ascent or depression is produced at the sides of the tube, which is greater in proportion as the diameter of the tubes diminishes. The ascent is termed the *concave meniscus*, the depression the *convex meniscus*, as in annexed cut, where the dotted lines represent the level of surrounding fluid.



In the same way, if two plates of glass approach each other in water, when the surfaces are sufficiently close to one another the water will *rise* between them, and the closer the plates the greater the elevation, the surface of which will be *concave*. If the same experiment be made with mercury instead of water, the mercury will be depressed between the plates, but to a less degree, and the surface will be *convex*. The laws according to which a fluid rises or falls in a tube have been experimentally determined, and are as follows:—When a tube of dry glass is plunged in a vessel of water, the attraction of the glass does not extend beyond the depth of the very thin film of water which would adhere to the interior surface if the tube were drawn out; for if the tube, previously moistened by such film, were plunged into water, the rise would be much less than in the other case; and, whatever be the material of the tube so moistened, the elevation of the water in it is found to be the same. When cylindrical tubes of different diameters are compared, the elevation is inversely proportional to the diameter. If the interior of the tube be conical, the elevation or depression in it is found to depend on the diameter at the upper part only of the elevation, and to be the same as in a cylindrical tube of that diameter. If the tube be double, one tube within another, the fluid rises to the same height in the interval between the two tubes as it would do in a tube with that interval for its radius.

Between two parallel plates, immersed at a very small interval, the fluid rises as high as in a tube with that interval for its radius. Between two plates vertically placed, but inclined at a very small angle, the fluid rises higher and higher as it proceeds towards the upright line of junction; and the curve of the upper surface of the fluid is an hyper-

HYDRODYNAMICS.

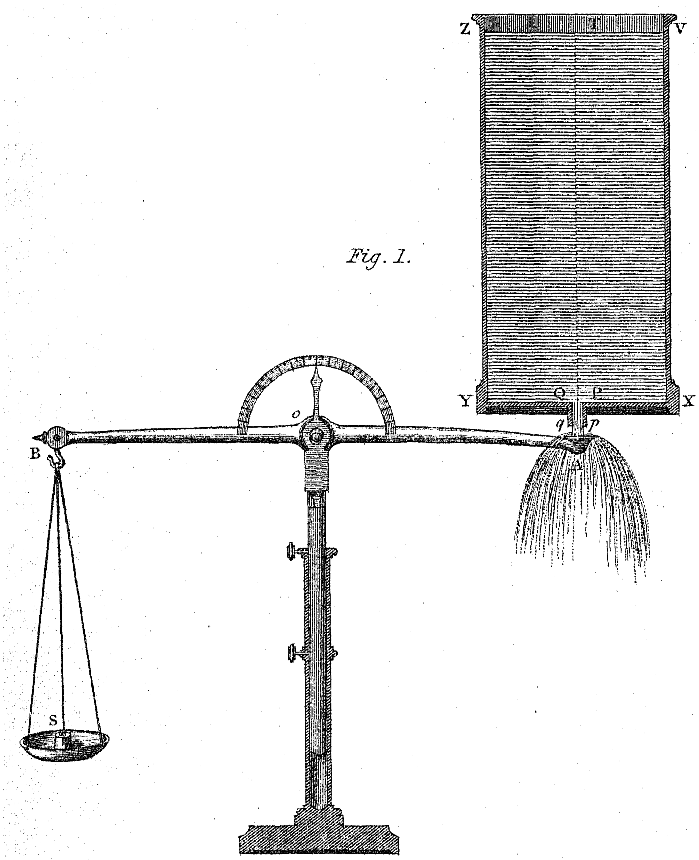


Fig. 1.

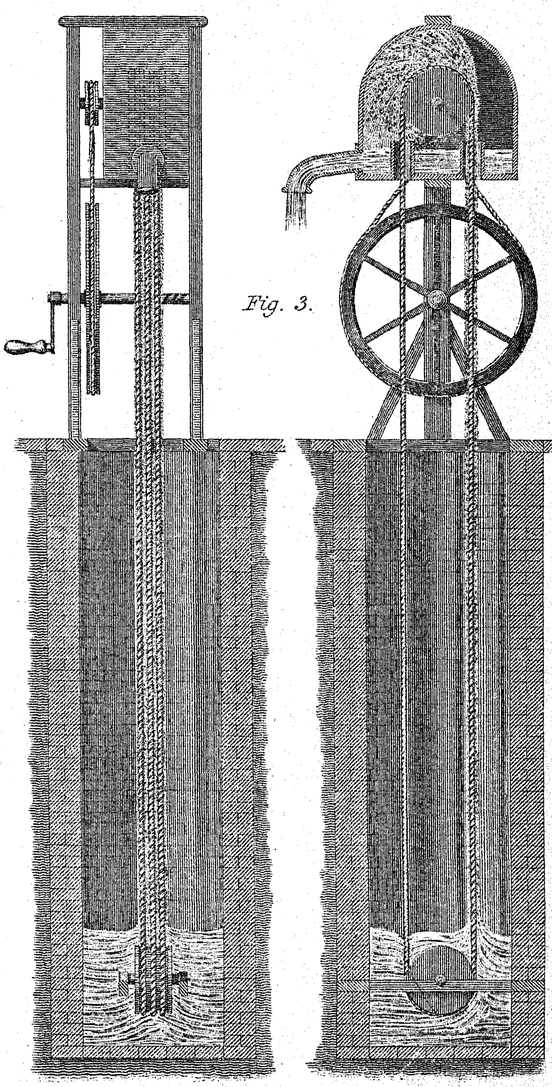


Fig. 3.

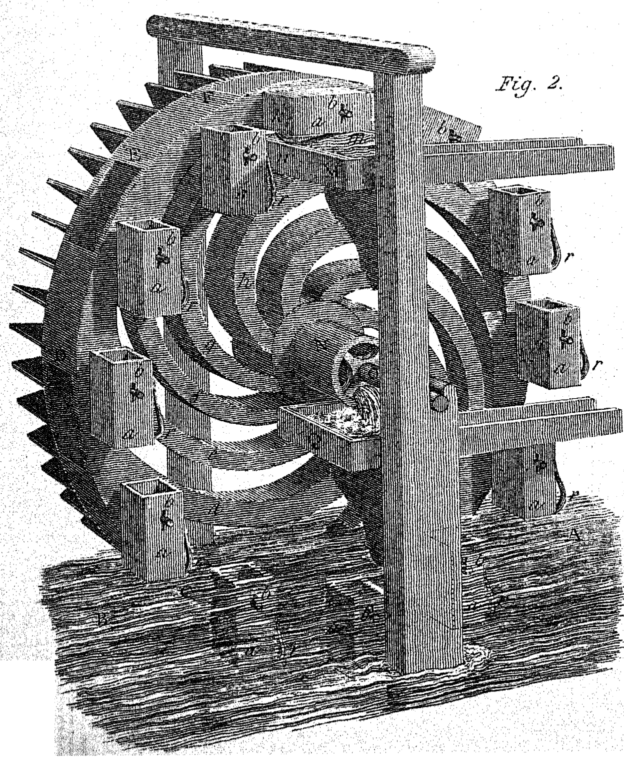


Fig. 2.

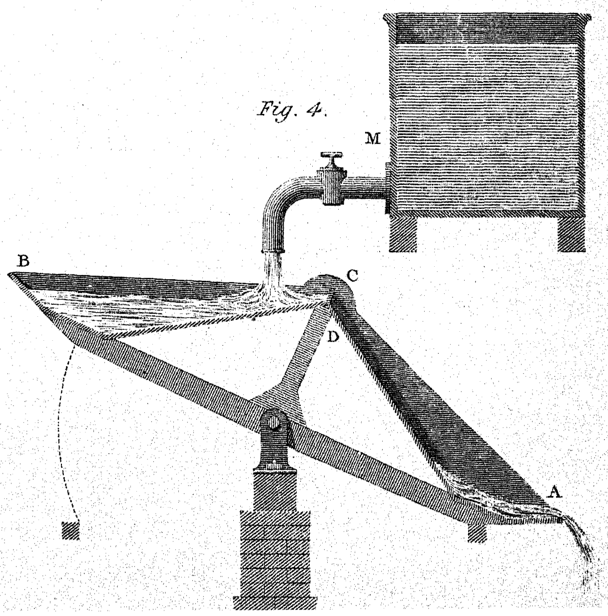


Fig. 4.

NATURAL PHILOSOPHY.

HYDRODYNAMICS

Fig. 2.

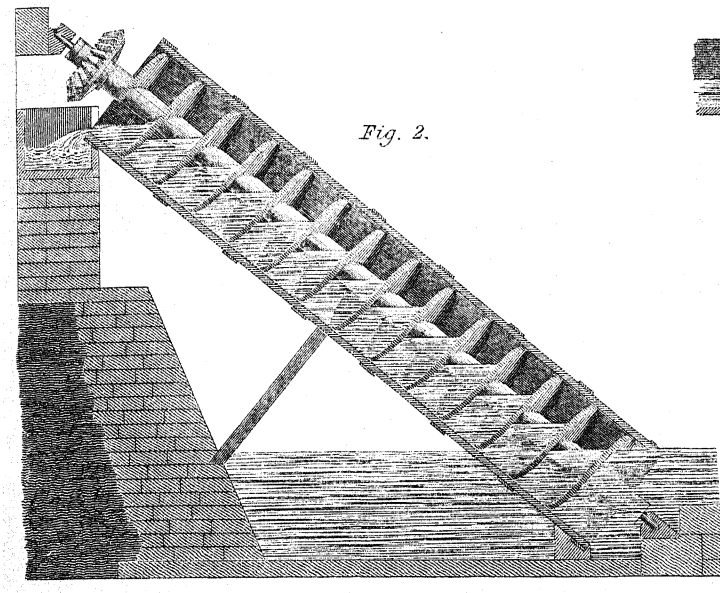
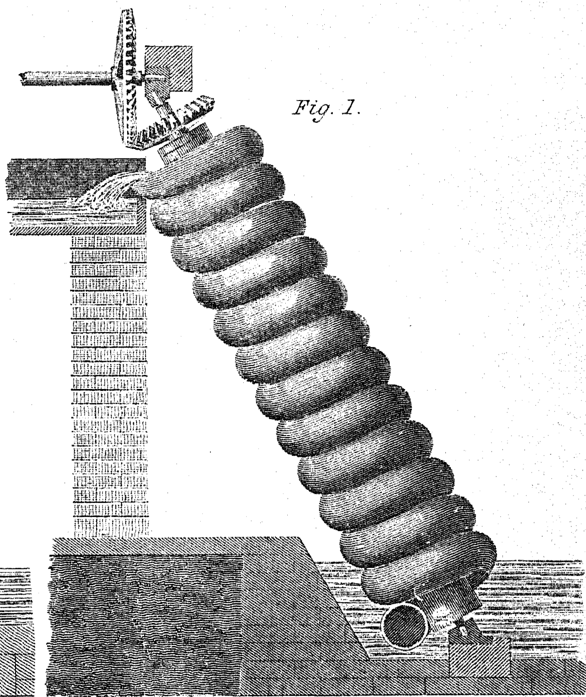
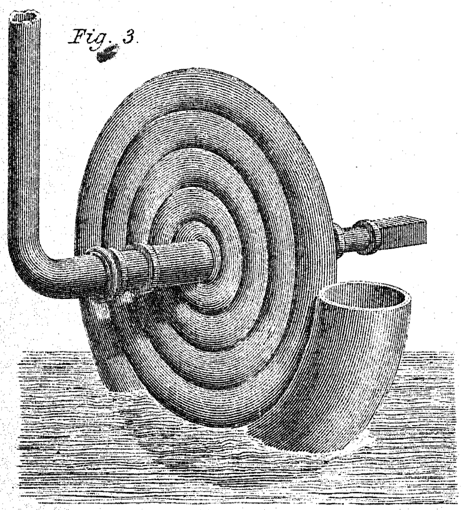


Fig. 1.



Screw of Archimedes in two forms.

Fig. 3.



Spiral Pump of Wirtz or Zurich Machine.

Side View of Chain Pump.

Fig. 5.

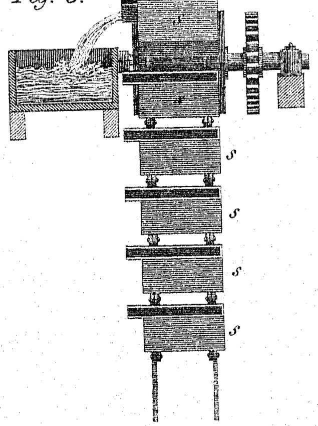


Fig. 4.

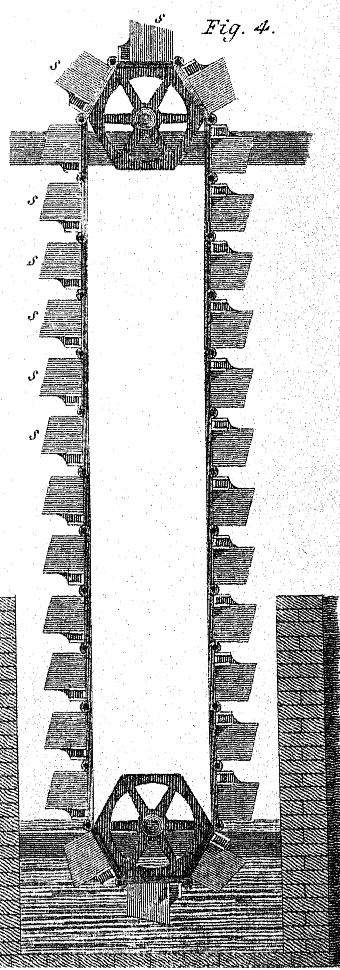
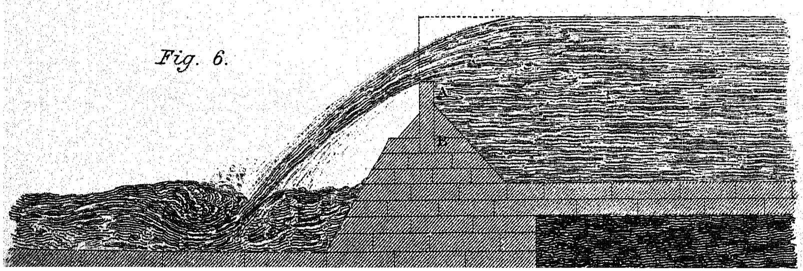


Fig. 6.



bola. The force exerted by capillary attraction is very great. When dry wooden plugs are driven into holes drilled into rock, and water is then poured over the ends of the plugs, the capillary force draws the water into the pores of the wood, which swells and splits the rock. In the same way it is owing to the capillary force retaining water in a cloth that it is quite impossible to wring or squeeze it dry. The capillary force never causes a liquid to flow through a tube; it is from this cause that the oil in a lamp wick, when not burning, does not overflow the wick, though so long as the lamp is burning, and the oil is consumed, the supply is continually rising up the wick. The most important law in connection with capillary attraction is known as *Jurin's law*, namely, that *the height of the ascent of one and the same liquid in a capillary tube is inversely as the diameter of the tube.* This law does not, however, apply with equal accuracy to the depression of liquids in tubes. When a liquid moistens a capillary tube, a very thin layer of the liquid is formed against the sides, and adheres even when the liquid sinks in the tube; the rise of the liquid in the tube therefore takes place inside a central tube of the same physical nature as itself, and this rise is consequently an act of cohesion. It is from this circumstance that the nature of the sides of the capillary tube is without influence on the height of the ascent, which has therefore simply reference to the diameter of the tube. With liquids that do not moisten the material of the tube, the capillary action is directly between the sides of the tube and the liquid; and as the nature and structure of the sides are never altogether homogeneous, and there is likewise always a thin layer of air on the inside which is not absorbed by the fluid, these two causes counteract to a certain extent the law of Jurin as regards the depression of fluids. When the surface of the liquid within a narrow tube, in contact with the air on both sides of the tube, is concave, it is evident that the pressure of the air immediately below the surface is less than the atmospheric pressure by a force due to the concavity of the surface, and that the pressure will go on increasing till at a depth corresponding to the mean level of the external liquid it becomes equal to the atmospheric pressure. When the surface is convex the pressure immediately below the surface of the liquid in the tube is greater than the atmospheric pressure by a force in proportion to the difference of the mean level of the liquid inside and outside of the tube; so that, with a concave meniscus, the force due to the surface tension acts in a direction *opposite* to gravity, lessening its effect, and with a convex meniscus the force due to the surface tension *increases* gravity.

The attractions and repulsions of bodies floating upon the surface of a liquid are due to the action of capillarity, and the laws by which this phenomena are governed may be stated as follows:—If two balls of any substance, as cork or pith, which are capable of being moistened by the liquid, are placed so near to each other that the surface of the liquid between them is raised, then attraction takes place and they are drawn together, and the same effect is produced when the balls are not moistened, as when two balls of wax are employed; but if one ball is moistened and the other remains dry, then when the curved surfaces of the liquid intersect they repel one another. When minute solid bodies heavier than water float upon its surface, it is because the bodies are not wetted by the water, and the amount of liquid displaced by the capillary depression around them is equal in weight to that of the body. It is from this cause that some insects can walk on the surface of the water, and that steel needles carefully placed will float if their surfaces in contact remain dry. The cause of the curvature of the surface of liquids in contact with solids depends upon the relation between the attraction of the solid for the liquid, and of the mutual attraction between the particles of the liquid; and as each molecule of the liquid in contact with the solid is acted upon by gravity, by the attraction of the liquid, and by the attraction of the body, according to the relative intensity of these forces, their resultant at the surface of the liquid adjacent to the body will determine whether it be either horizontal, concave, or convex.

The tendency of all fluids is to assume a spherical form. Rain in falling from the clouds assumes the form of spherical drops. Molten lead subdivided by passing through a fine sieve, in dropping from a height assumes a globular shape; upon this principle the shot tower is constructed and shot is made. Olive oil poured gently into a mixture of three parts of alcohol to one part of water, giving a mixture the density of the olive oil, will be found to remain suspended in the mixture in the form of a sphere, the specific gravity of the two liquids being equal. Quicksilver scattered over a smooth surface of wood or glass will subdivide itself into minute spheres. The ordinary soap bubble blown from a solution formed of soap and glycerine illustrates the nature of the forces which act on a fluid surface. When the bubble is distended by the pressure of the air blown in by the mouth through a tube, the force expended is stored up in the film of the bubble, as upon removing the pressure the bubble will immediately contract and drive the contained air out of the bubble through the tube. Therefore, when two fluids which do not combine are in contact with each other, the surface separating them is in a state of *tension*, and the surface particles approach one another. This surface tension resides in the thin film separating the fluids, and does not extend to any appreciable depth below the surface, and arises from the particles in the interior of the fluid being subjected to equal forces on all sides, while those on the surface are under the influence of different molecular attractions, which result in the contraction of the boundary surface. To this action is due the spherical form of the drop and that of the soap bubble. So that between any two liquids that do not mix, or between a solid and a fluid of any kind, there is a definite surface tension, the value of which for a unit length is called the coefficient of superficial tension or capillarity; and this surface tension is found to be greatly influenced by the temperature of both media, decreasing as the temperature rises, and disappearing altogether when the temperature is no longer definite between the two media. At a temperature of 20° C. the tension of a surface of water in contact with air is 81, between mercury and air 540, alcohol 25·5, and of olive oil 36·9 units of force.

The free surface of a liquid, such as water, in contact with air, has greater cohesion than any layer of the liquid below the surface, for every particle at the surface is attracted by the adjacent particles in all directions except in the direction above the surface. The lateral attractions compensate each other, but as there is no attraction above the surface to counteract the attraction from below, the latter will exercise a considerable pull towards the interior, so that the mobility of the surface particles will be less than the mobility of the particles of the liquid below the surface. This *surface tension* is greater as the cohesion between the particles of the liquid is greater.

DIFFUSION.

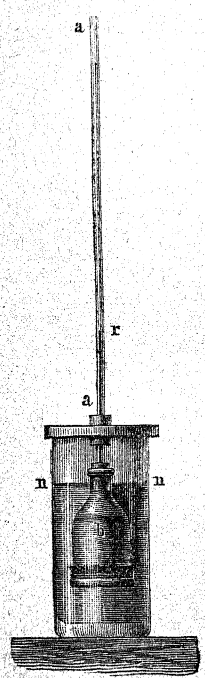
When the surfaces of two liquids of different densities capable of permanent admixture are placed in contact with each other in the same vessel, they gradually become intermixed and combined notwithstanding their different specific gravities. This process is termed *diffusion.* If a cylindrical glass vessel be filled about two-thirds its height with a solution of litmus, and then by means of a long tube and funnel, hydric-sulphate be very carefully introduced into the lower part of the jar, the acid after a time will be found to have diffused itself through the litmus by the red change of colour the solution has acquired. In the same way, if alcohol be carefully placed upon the surface of water in a vessel, the two will after a time be found to be intermixed by diffusion. The results of experiments upon the diffusion of liquids show that when solutions of the same liquid, but of different strengths, are taken, the quantities diffused in equal times are proportional to the strengths of the solutions; thus, taking four different solutions of common salt containing 1, 2, 3, 4 parts to 100 parts of water, the quantities diffused in a given time were found to be closely in the proportion of 1, 2, 3, 4. The quantity of salt diffused in equal times was found to increase with the temperature; with a 4 per cent. solution, and with a rise of temperature of 15° C., the diffusion increased over one-third. When the solutions employed contained equal weights of different substances, the quantities

diffused varied with the nature of the substance. If a solution be taken of two different salts which do not combine, each will follow its own rate of diffusion. A method is therefore supplied for their separation to a certain extent from each other. If a mixed solution of two corresponding salts of potash and soda be placed in a phial, and carefully immersed in a jar of water, the potash salt, being more diffusive than the soda salt, will escape into the water outside the phial, while the soda salt will remain relatively concentrated in the phial. This process of separating bodies based on their unequal diffusibility is called *dialysis*, and is found to be of great value in laboratories and for pharmaceutical purposes. The approximate time of the diffusion of equal mixtures of different substances, taking hydric chloride as unity, is as follows:—

Hydric chloride,	1
Sodic chloride (common salt),	2·33
Cane sugar,	7
Magnesic sulphate,	7
Albumen,	49
Caramel,	98

Hydric chloride was found to be the most diffusible, and albumen one of the least diffusible. Comparing common salt with sugar-candy and albumen, it was found that with solution of 20 parts of the solid substance in 100 parts of water, exposed for eight days at a temperature of 16° C., the specific gravity of the diffused solutions were respectively 1·126, 1·070, and 1·053.

Examining the different diffusibility of various substances, Graham has divided all bodies into two classes, those which are incapable of assuming a crystalline form and which diffuse very slowly in water, but which are capable of forming a medium like water, and which are distinguished by the sluggishness of the molecules composing them. To this class belong starch, gum, hydrated alumina, albumen, gelatin, dextrin, and many organic compounds. These bodies he calls *colloids*, and their solutions arrest the passage of other colloids; but through them other substances susceptible of crystallization, which he calls *crystalloids*, are capable of diffusion. Colloids are generally bodies of high atomic weight, and it is probably owing to the larger size of their molecules that the difficulty of their passing through minute apertures arises. Crystalloids, on the other hand, diffuse rapidly through water and through a porous diaphragm formed of some insoluble colloid. This may be demonstrated experimentally by taking a piece of well-sized paper free from porosity. Let the paper be thoroughly wetted on both sides, and laid upon the surface of some water contained in a vessel, the opening of which is smaller than the paper. Depress the paper with the finger, so as to produce a small cavity, and place within the depression a mixed solution of cane-sugar and gum-arabic, about 5 per cent. of each. After a lapse of some twenty hours the water will be found to contain about three-fourths of the sugar, which will have passed through the paper, and the gum will be left behind.



One result of the phenomena of diffusion is the interchange of liquids through porous diaphragms. These phenomena are shown by means of the endosmometer (see cut). This is a long tube, *a a*, ending in a bottomless flask, *b*, the bottom of which is closed by a piece of membrane such as bladder. The flask is filled with a liquid denser than water, such as syrup, and is immersed in pure water so that both solutions coincide in height at *n n*. The liquid is found gradually to rise in the tube to a height, *r*, which may be several inches. At the same time the level of the external water is lowered. The external liquid has therefore passed through the membrane and mixed with the internal liquid, while at same time another portion of the latter has passed outward. The flow of the liquid toward that which increases in volume is termed *endosmose*, and the current in the opposite direction is *exosmose*. The height of the ascent in the endosmometer varies with different liquids. In general it may be said that endosmose takes place towards the denser liquid, though alcohol and ether behave in this respect as if denser than water. It is by the action of exosmose that the transmission of fluids takes place through the tissues of plants. The parts of vegetables may be highly charged with fluid by placing them in water, and may be depleted again by simply placing them in a fluid of greater density than the water they contain, the cell walls of their structure being the diaphragms through which the exosmose action is carried on and maintained.

LOGIC.—CHAPTER V.

CRITERIA OF TRUTH — FORMATIVE LAWS OF THOUGHT — PRINCIPLES OF INFERENCE—REGULATIVE LAWS OF THOUGHT.

Logic mainly deals with mediate reasoning, and does not largely employ its efforts on immediate inferences. There are facts in thought which all logicians must accept and cannot explain. Men cannot reason without assuming that thought is an efficient power in the discovery of truth. Some immediate impression must be made before any mediate one can be recognized. We cannot prove everything, or the linked chain of human reasonings would stretch backward in an infinity of retrogressive efforts to get at *the* first link, and even when we had got that length—supposing, for the moment, that it were possible—we should still require to investigate the origin and qualities of the matter of this earliest thought, the ground and law of the determination upon the point at which thought had first arrived, and the reality of the fitness of mind thus, in its primeval and untried state, to decide definitely and trustworthily on the topic originally demanding the active exercise of thought. The mind must begin somewhere and with something. Logic assumes the power of thought stimulated into, and possessed of, experience. Experiences might play throughout the universe for ever as a wild mass of possibilities if there were no conscious minds in existence to receive, be impressed by, and exercised upon them. And mind might revolve in an eternal whirl of unadvancing syllogistic revolution were there no matter furnished to thought, by experience, on which it could proceed to work. If mind be consciously known to operate in the production of thought, and if thought is really produced, it is self-evident that there are in evolutionary activity (1) a power of thinking, and (2) something which may be thought about. Thought is a self-evidencing power. We cannot get beyond and behind the intuition of it—the primary immediateness of our experience of a capacity to think made undoubtedly manifest to us in some actual operation of thinking going on within us, and so revealed to us in such an act. But, if we do think, we must think on or of something, and must realize more or less distinctly the difference between the act of thinking and the object upon which that act was known to operate—in other words, experience realizes, along with itself, intelligence. Consciousness is the awakened perception in the intellect of its own existence in the act of knowing experience. Therein the implicit becomes explicit.

This fact legitimates immediate self-evidence as a real (and possibly valid) source of truth. But though undeniably real, the conditions and requirements of reasoned truth make it requisite for a thinker to know not only (1) *that* a perception is self-evident, but also (2) *why* it is self-evident, and (3) *to what precise extent* it is so. It is not enough to say to the critical analyst of thought that a perception is seen at once by the contemplative mind; it must be shown to be (1) incapable of resolution into mediate elements, (2) to be free

from admixture of imagination, and (3) to be presented, not represented, to the mind. Whatever it demands acceptance for must therefore be a minimized ultimate in experience, unable to be reduced to lower elements, and really a first truth—a primary mental fact in apprehension. This immediately perceived experience supplies the most convincing of all truths, provided it undergoes the tests of an unsparing logical criticism as to its distinct and absolute immediacy. Our ideas of existence, space, number, personality, come to us with more or less self-evidencing power.

Again, if intellect is incited to apprehensiveness by experience, that experience originates in us the sense of the fact of necessity. It is impossible for us to think away any really valid self-evident perception. It is a necessity of the perceptive mind to take it in and to acknowledge it. Many logicians regard this felt necessity of belief in a perception as the most potent and essential test of the truth of a perception. Is it conceivable, they say, to think it away? If so, it is not necessary to believe it. That is a vague and vagrant criterion of experiences as facts. It may prevent us from accepting any other perception as essential and true; but does not, of itself, compel acceptance of *it* as a necessity of thought unless it first and really impress us with the idea of irresistibility. But this idea of irresistibility, this affirmativeness of experience, may be tested (1) as to its self-evidence, and (2) as to the inconceivability of its being other than it presents (or has presented) itself to the mind. The thinkable is the possible, the unthinkable is the impossible (to us). That which has so self-evidently impressed itself on us that we cannot unthink it, erase it from our minds, regard it as non-existent and unreal, is the necessary. We cannot but consider perception, consciousness, and the existence of impressions made on them as real necessities of thought. We must think what comes to us by experience; but we require to make ourselves sure (1) *that* it actually is experience, (2) that it is no other thing than experience, and (3) that it is clearly and distinctly an ultimate and presented, not a represented, experience.

Self-evidence is a *perceptive*, necessity is an *intellective*, test. We cannot dislodge these from our individual mental nature. Truth, however, as that which may be trusted in, cannot be individual and singular. It can only register among its possessions those ideas on which there is (or may be when properly considered) a general *consensus* or practical intellectual agreement among men. This is the *communis sensus*—not so much the common sense of the philosophers as the general assent of mankind—on which men rely when they generalize experience and formulate it into truths. It implies that there is a general average of powers in men, and that these, when exercised upon the same sort of objects, in as nearly as may be the same sort of way, result in communicating the same, or at least very similar impressions—impressions which, among the complexities of experienced thought, may be traced as, on the whole, self-same in their results. This induction from the experience of all men as to the revelations of the senses and human faith in their perceptions; as to the processes of the activities of mind and man's conviction that what they spontaneously do under the stimulus of presentative knowledge affords a trustworthy foundation and ground for representative knowledge; as to the capacities of the mind and the general selfsameness of the operations in which they engage while active in perception, reflection, and reasoning—we accept as determinate testimony to the series of truths which men accept as true, and upon which they act unanimously in common. These universally received original and primary truths, with reliance upon which all men act and expect all other men to act, are quite rightly considered by logicians as immediate apprehensions, not adventitious but native, from which, as sources, derivative truths may be received and deduced—positive determinations of the intelligence, to act in opposition to which would be unwise and unsafe. They are accepted as realities free from the contingencies of custom, fashion, or metaphysical inventiveness, and such as normally arise into consciousness so soon as the capacities of human thought are operated upon by the capacities of things without—at once *innate*, as resident in and essential characteristics of the mind; and *connate*, as being made manifest by the co-operation of mind and matter. We possess faculties, powers capable of efficient operation. How we came into possession of them we cannot trace, nay, what are the earliest moments and methods of their activity we cannot indubitably discover, however painstaking our analysis may be. But that mental discernment exists in man, as a special primary normal endowment, we never doubt, and that when similar objects are presented to or impress their efficiencies on this power of intuition or mental beholding, all men's minds agree in their perception of them, and gain from them very similar original suggestions. We distinguish readily enough, after experience and investigation, that there is a truth that *is*—a truth of transitory and passing fact, as, "I see that man's shadow on the grass;" a truth that *must be*—a truth of which no doubt can enter a sane mind, as, "Two straight lines cannot inclose a space;" and a truth that *may be*, as, "All men ought to be equal in the eye of the law." Our perception of *self* as a something consciously existing may be due to muscular structure impressed by resisting force, and leading to our apprehension simultaneously or immediately of something other than self, an outer world; our sympathies may have their origin in our instincts, but they imply that we have come to know others as distinct from (though very similar to) ourselves; our sentiments may be the results of our sympathies, but they are so because we perceive a general tendency in others to feelings similar to our own—a brotherhood of nature, emotion, and thought. In the same way we realize specific informants of each sense, and unite our perceptions of them into conceptions such as we feel sure all men will realize from them on their being similarly excited. Thus music is composed to gratify the ear, pictures are painted to satisfy the eye, poetry is written to stir the emotions, goods are prepared for the market, because we have a conviction of the general selfsameness—the common sense—of men. It does not follow, however, that we are to receive the single, separate, and individual impressions made on our minds as truths possessed of the highest possible certainty—as those of which we should seek no further verification. Experience and information, as they extend their range, always bring us in newer, fresher, and more thorough means of confirmation, as well as encouragements to fuller faith in, and more intelligent reliance on, those cognitions, beliefs, and judgments which are excited in us on the earliest awakening of the mind to personal consciousness and activity.

Logic teaches us to test every idea which presents itself to us, claiming our acceptance as *true*. Without being cautioned to constant wakefulness of mind, we might by mere indolent passivity of reception, or by the ready operations of prejudice, accept as true what ought to be called upon to produce verified credentials, and which might be found to have really none to produce. Associations work together, and interweave facts and fancies in our minds; a lengthened and habitual thinking of things in union tends to make us regard them as indissolubly bound together, and to take things which are really complex as exceedingly simple facts. For instance, it seems to us the most easy and natural thing in the world to indicate multiplication by ten by placing a zero after a cypher (as, 2 : 20, 200), but the history of arithmetical notation shows us that what appears the easiest of all processes was only arrived at after a long-continued endeavour to acquire some means of organizing numbers in a compact and available method. So do we also think the simplest and plainest of all perceptive revelations are those which we receive through sight; distance, colour, form, light, shade, pleasure, and knowledge are all so wedded together into an associated unity, that when we say we see, we imply all these in one, though we know that they can by analysis be resolved into distinct elements.

We require to learn to distinguish the primary truths of intelligence from the contingent truths of fact—science, the laws of things, from history—the facts of experience. We reason, as a natural function of intelligence; but logic proceeds to teach us to analyze the process of reasoning, that we may attain a knowledge of the general principles which guarantee the cogency of reason; that we may be able to distinguish and discriminate immediate from mediate inference, demon-

strative from probable reasoning, and indicative from deductive investigation; as well as have distinctly and consciously before our minds, when they are required for guidance, the laws, the principles, the axioms, and the maxims of discursive thought. Perception is the mirror of the impressions made on mind by the outer world, and intuition is the impression of ideation received from the impressions so made. When we know this impression as the representation of a presentation we have a notion. Notions come to us in a complex casual form, unassorted and without their relations one to another being precisely noted. Hence judgment is called into exercise to determine these relations and to place them in propositions before the mind, so that by inferences fairly formed they may have a place assigned to them in the system of syllogized or reasoned-out thought.

Inference is derivative. To syllogize is to gather together and place in proper order those premises or primary propositions out of which further knowledge may be gained. As a preliminary to syllogizing, the logician commends the critical investigation of every term and proposition, so as to make sure that the ultimate ground of each proposition rests upon some self-evident, necessary, or universally accepted presentation of truth or fact, or may be traced up to these. It places the following preliminary principles before us as the basis of reasoning:—(1) Everything is what it *is*—not what it *appears* to be, but what it *proves* to be. The mind must be able to receive impressions which are *true* to it, and may be accepted by it as *certain*. We have only five senses, and of course we do not know so completely all the inner essences of things now as we might if we had fifty; but, so far as our powers reach, we must accept our properly observed and analyzed conceptions as true in their contents. (2) What is not is not what is, or what is is not what it is not—there can be no real contradictions in thought accepted by thought as *true*. Belief in, and acceptance of, contradictions are absurdities which common sense rejects and logic repudiates. (3) All true thought is self-consistent; when therefore we accept one thought we must reject its contradictory. (4) No idea can (or at least should) be entertained in the mind without sufficient reason for its acceptance, and for determining that it is what it is, and what are its relations; in other words, every idea must have a sufficient reason for our belief in it as a genuine effect of a real cause.

CHEMISTRY.—CHAPTER VII.

THE EARTHS—ALUMINIUM—SILICON—BERYLLIUM OR GLUCINUM—ZIRCONIUM—THORINUM—YTTRIUM—CALCIUM—BARIUM—STRONTIUM—MAGNESIUM.

THE greater portion of the earth's crust is mainly composed of *eight* elements, which form the rocks of various degrees of hardness, closeness of texture, and aspect; and these rocky materials are often found becoming disintegrated and mouldering into small particles. The process of mouldering produces no change, further than breaking down the cohesion of the rock; for the loose powdery matter at the foot of the rocky mountain is found to contain precisely the same ingredients as the rocks from which it was produced. This debris constitutes *earth*, and in process of time, becoming mixed with organic matters, forms *soil*. As different rocks are composed of different materials, the earthy products which result from their disintegration differ also in the nature of their ingredients.

Pipeclay is a familiar substance, and the sapphire is well known—a gem of various colours, and second, in point of value, only to the diamond. These substances are very dissimilar, and both seem to differ essentially from common roofing slate; yet the sapphire is almost a pure specimen of that peculiar kind of earth, *alumina*, which constitutes the chief ingredient of pipeclay and roofing slate, and which indeed gives plasticity to all clays, whether existing in soil or dug from the kaolin pit to form translucent china. It has obtained this name in consequence of its being the basis of alum, from which it is easily procured in a state of purity. To exhibit it in this state it is only necessary to make two solutions—one of alum and the other of potash—and to pour the one solution into the other. Thus a bulky white precipitate is obtained, which is alumina in a state very nearly pure. This white precipitate presents no apparent analogy to Oriental ruby (red sapphire), which is the purest specimen of alumina that mineral nature affords. In the gem the earth is crystallized, and derives its beautiful and much-valued colour from a very minute admixture of iron—not more than 1 per cent.

ALUMINIUM (Al; atomic weight, 27·4; specific gravity, 2·6).—This metal occurs in large quantities combined with silicon and oxygen in felspar, and all the older rocks. Metallic aluminium is obtained by passing the vapour of aluminium chloride over metallic sodium. It is now manufactured on a large scale both in England and France, and from its lightness and its bright silver lustre is largely used for the metallic portions of optical instruments. The alloy of aluminium with copper is remarkable for being similar in appearance to gold.

Alumina (AL_2O_3; specific gravity, 3·9) is the only oxide of aluminium known, and is largely used in dyeing and calico printing as a mordant, as it forms insoluble compounds called *lakes* with vegetable colouring matter, and renders the colour permanent by fixing it in the pores of the fabric; such colours are termed *fast*.

Another very plentiful earth, which, like alumina, is abundantly diffused throughout nature, is that which composes *flint*. The Latin name for this mineral is *silex*, and hence the earth of which it is constituted has obtained the name of *silica*. It is found in almost all solid mineral substances, and forms a large portion of the bulk of those rocks which compose the solid parts of our globe and the sand which lies valueless on our shores. Among geologists it takes the name of *quartz*, in its common crystalline state; and when these crystals are large, pure, and well defined, the mineral is known as rock crystal. It is the main constituent of various gems. Amethyst, cat's-eye, onyx, and sardonyx are all nearly pure silica, coloured by some metallic oxide; and the much-valued gem called "precious opal" consists of nothing more than nine parts of this earth combined with one part of water. The stone called "hydrophane" is a more curious specimen of it. This stone is opaque till plunged into water, when it becomes one-half heavier and transparent like glass.

Silica differs essentially from alumina, yet both are frequently found associated together in the same mineral. Thus porcelain clay contains nearly equal parts of these earths; and, uniting with the oxides of iron, they form the reddle, or red ochre, of Staffordshire and Derbyshire. Fuller's earth, and the hard stone called agate, are also constituted of alumina and silica, and together they form the main part of all soils. In making earthenware a due proportion of both these earths is requisite; for, were alumina alone used, the ware could not be sufficiently burned without shrinking too much, and even cracking, and a great excess of silica would lessen the tenacity and render the ware brittle.

Silica is the chief ingredient in glass, and indeed of all vitreous substances. It is infusible alone; but, when intimately mixed with potash or soda, it may readily be fused, and if no other ingredient be added, the glass which is formed will have the property of being soluble in water. Flint glass is rendered insoluble by admixture of oxide of lead, and crown and common window-glass by lime. Common bottle-glass differs from the first of these in containing no lead, from the last in containing some iron, and from both in being formed of very impure materials—as common red sand and soap-boilers' waste ashes. Artificial gems, or *pastes*, are similarly formed, by fusing silica with soda, and adding some metallic oxide, to give the required colour.

SILICON (Si; atomic weight, 28), next to oxygen, is the most abundant element known. It does not occur in the free state, but always combined with oxygen to form silicon dioxide or silica. Silicon also occurs combined with metals and oxygen, forming metallic silicates, and these form the greater part of almost all known rocks, especially the primary rocks.

Silicon dioxide or *silica* (SiO_2; atomic weight, 59·92) is the only known oxide of silicon. Amorphous silica occurs in nature as opal. Flint, agate, and chalcedony are mixtures of amorphous silica with quartz. Silica is infusible except at the highest temperature of the oxyhydrogen blowpipe,

when it melts to a colourless globule, and it cannot be vapourized at any known temperature.

Silica and alumina are frequently associated together, often indeed forming gems of great beauty, as the garnet, the Brazilian topaz, and the precious emerald, of which the beryl is a species. These last are not, however, composed entirely of silica and alumina, but contain also another earth, to which chemists have given the name *glucina* (from a Greek word, *glukus*, sweet), on account of its property of forming, with other substances, combinations which have a sweet taste. It is, however, unlike the two earths with which it is associated in the emerald and beryl, a very scarce substance; it occurs, indeed, only in another very rare sub-species of the emerald, found in Peru and Brazil, and known to mineralogists under the name of *euclase*.

BERYLLIUM or GLUCINUM (Be; atomic weight, 9·3; specific gravity, 2·1).—This rare metal occurs as a silicate, either alone, as in phenacite, or associated with other silicates, as in beryl, emerald, &c. Metallic beryllium is obtained by passing the vapour of the chloride over melted sodium. It is a white metal, which may be hammered and rolled into sheets like gold; its melting point is below that of silver. It does not decompose water at the boiling heat. Hydrochloric and sulphuric acids dissolve it with evolution of hydrogen. It forms a monoxide (BeO), and a series of soluble, colourless salts which have a sweetish taste.

The gem called zircon (a species of the hyacinth), found especially in Ceylon, affords another rare earth, which has been named *zirconia*, in commemoration of the source whence it was first obtained. It is associated in zircon and hyacinth with silica, and is distinguished from alumina and glucina by the character of the compounds which it forms.

ZIRCONIUM (Zr; atomic weight, 89·6).—This rare metal is intermediate in many of its properties between aluminium and silicon. Its oxide, zirconia, was first obtained from zircon by Klaproth in 1789. Zirconium, like silicon, is capable of existing in the amorphous, crystalline, and graphitoidal states. Crystalline zirconium forms very hard brittle scales, resembling antimony in colour and lustre; it burns in the air only at the heat of the oxyhydrogen blowpipe, but takes fire at a red heat in chlorine gas.

THORINUM (Th.; atomic weight, 231·5; specific gravity, 9·4).—Another of these scarce earths has been obtained from a Norwegian mineral named *thorite*. This is also a compound of silica with its new associate, which has been named *thorina*, after the mineral which affords it. Like those earths already noticed, it is white, but exceeds them all in weight—its specific gravity being as much as 9·4, which is considerably greater than that of iron, 7·8, or even copper, 8·9.

Another distinct earth has been obtained from a rare stone found at Ytterby in Sweden, and hence called *yttria*. It resembles glucina in the property of forming combinations which have a sweetish taste; but most of them are distinguishable by a pale rose colour.

YTTRIUM (Y; atomic weight, 89·6) and ERBIUM (Eb; atomic weight, 166·0).—These metals exist as silicates. *Erbia* (Eb_2O_3) does not melt at the strongest white heat, but aggregates to a spongy mass, glowing with an intense green light, which, when examined by the spectroscope, exhibits a *continuous* spectrum, intersected by a number of bright bands. *Yttria* (Y_2O_3) is a soft, nearly white powder, which, when ignited, glows with a pure white light, and yields a spectrum not containing any bright bands, like that of erbia.

Marble is a well-known substance. Its whiteness in some specimens, and its beautifully variegated hues in others, together with its high lustre when polished, have introduced it as an admirable material for sculpture and ornamental architecture. It is found of every variety and mixture of colour, from pure white to pure black. The purer specimens are highly valued; yet they are all nearly the same in chemical constitution, and differ in nothing except in their crystalline texture from common limestone and chalk—of which whole mountains exist in some parts of the world.

The earth of which limestone is composed is never found pure in nature, but is readily procured in that state by subjecting a piece of chalk to a white heat. The process of lime-burning has long been common in most parts of the world. The limestone is broken small and stratified with fuel in a kiln: this is set on fire, and heats the stone red-hot. During the burning the stone becomes nearly one-half lighter, and its properties are totally changed. It is now quicklime. Formerly it might be placed in water without undergoing any change; but if water be now poured upon it, it is immediately absorbed, and the lime appears as dry as ever. In some time, however, it grows hot, swells, bursts, discharges steam, and falls to powder. This powder is called slaked lime, and weighs one-fourth more than the quicklime from which it was formed. Exactly the same phenomena are exhibited, whether the material used be common limestone, chalk, white, black, or variegated marble, transparent Iceland spar, oyster shells, or coral—all these are composed of the same substance, with a slight difference only in purity.

Quicklime is the earth of limestone—it is *lime*, properly so called. In transparent Iceland spar, which is pure crystallized limestone, it is found combined with carbonic acid (the gas which constitutes choke-damp), in the proportion of $28\frac{1}{2}$ lime to 22 acid. Black marble is limestone combined with a small portion of bituminous matter. In gypsum and alabaster it is combined with sulphuric acid (vitriol) and water. By burning gypsum to drive off the water in it the substance forms plaster-of-Paris, so much employed in making casts. Animal bones are also mainly composed of lime in combination with phosphorus and carbonic acid. Combined with another substance called fluorine, lime constitutes Derbyshire spar.

Perhaps none of the earths are used for so many purposes in the arts as lime. In making mortar for building it is indispensable. For this purpose it is mixed with sand (silica), for which it has a great attraction, and without which the mortar never hardens. When the ingredients are mixed in the proper proportions the lime gradually absorbs carbonic acid from the atmosphere; and this, in a series of years, passes again to the state of unburnt limestone. By the tanner lime is used to dissolve the gelatinous part of the skin, and to facilitate the removal of the hair. In sugar-refining it is employed to free the sugar of an acid which prevents its crystallization; and by the soap-boiler to deprive his solutions of carbonic acid, which hinders the tallow and alkali from combining.

The agriculturist uses lime extensively as a manure, and the manufacturing chemist combines it with chlorine to form bleaching-powder. In the manufacture of iron it is used as a flux, although it is alone infusible; and the apothecary dissolves it in water for medicinal purposes.

There are two minerals, very different from limestones and from each other, and which are very commonly found associated with carbonic acid; but when burned, they afford earths which agree with lime in the property of swelling and becoming hot when cold water is poured upon them. Like lime, they undergo the process of slaking. These minerals are named by chemists carbonate of baryta and carbonate of strontia; and by mineralogists barolite and strontites. From these names the earths are called baryta and strontia.

CALCIUM (Ca; atomic weight, 39·9; specific gravity, 1·58) is one of the most abundant and widely diffused of the metals, though it is never found in the free state. As carbonate it occurs in a great variety of forms. Calcium is a light yellow metal, and it is nearly as hard as gold, very ductile, and may be hammered out in exceedingly thin sheets. It tarnishes slowly in dry air, and decomposes water rapidly. It burns with a bright flash of light.

Calcium monoxide or lime (CaO). Pure lime is white, and frequently of great hardness. When moistened with water it slakes violently, evolving heat, and crumbling to a soft white powder called calcium hydroxide, or slaked lime ($CaOH_2O$). Lime-water is prepared by agitating cold water with excess of calcium hydroxide, in a closely stoppered vessel, and after subsidence pouring off the clear liquor. The hardening of mortars and cements is greatly due to the gradual absorption of carbonic acid. Hydraulic mortars which harden under water are prepared by carefully heating an impure lime containing clay and silica; a compound silicate of lime and alumina is formed on moistening the powder, which then solidifies and is unacted upon by water. When lime is used in agriculture, its action is twofold; destroying

the excess of vegetable fibre and matter contained in the soil, and also liberating the potash for the use of the plants from the heavy clay soils by decomposing the silicate.

Calcium carbonate, or carbonate of lime ($CaCO_3$), occurs in widely different forms, as chalk, limestone, coral, and marble; many of these vast deposits being made up of the minute remains of microscopic sea animals. Carbonate of lime is almost insoluble in pure water, but readily dissolves when the water contains carbonic acid, forming then what is termed *hard water*. When hard water is boiled it deposits a crust of calcium carbonate, owing to the escape of the carbonic acid. If air from the lungs is blown through clear lime-water a white precipitate of carbonate of lime takes place owing to the carbon dioxide in the breath.

Calcium chloride ($CaCl_2$) is a soluble salt formed by dissolving limestone or marble in hydrochloric acid. When the solution is evaporated, colourless needle-shaped crystals of the hydrated chloride are formed. When these are dried the mass still retains $2H_2O$, and takes up moisture with great avidity. It is greatly used, when strongly desiccated, for drying gases, and for the production of artificial cold by being mixed with snow or powdered ice.

Chloride of lime, or bleaching powder ($Ca2ClO$), is made from calcium hydrate slightly moistened and exposed to the action of chlorine gas, which is readily absorbed and a compound produced—the bleaching powder of commerce—which is used on an extensive scale for bleaching linen and cotton goods. In preparing bleaching powder it is necessary to avoid all elevation of temperature, which is accomplished by supplying the chlorine gas slowly at first. The product is a soft white powder, attracting moisture from the air, and giving off an odour different from that of chlorine. It is soluble in about 10 parts of water. The solution is strongly alkaline. The composition of bleaching powder was at one time considered as a compound of lime and chlorine; but its atomic constitution is really represented by the formula $Ca\left\{\begin{matrix} Cl \\ OCl \end{matrix}\right.$, the molecule being decomposed by water into chloride and hypochlorite. In an open vessel the compound is rapidly decomposed by the carbon dioxide of the air. The value of commercial bleaching powder therefore varies with its age, and the care originally taken in its manufacture. The best bleaching powder rarely contains more than 30 per cent. of available chlorine. A new process of preparing chlorine on a large scale has recently been discovered. It is based upon the fact that when hydrochloric acid gas and air are passed together over heated copper sulphate, the hydrogen of the hydrochloric acid and the oxygen of the air combine together, forming water, while the chlorine is set free. The copper sulphate, which undergoes no change, acts for an indefinite length of time. Chlorine for the production of bleaching powder is now manufactured upon this plan in immense quantities.

The spectrum of calcium is a very peculiar one, containing a number of distinct bright lines, by which the presence of the metal is readily detected.

BARIUM (Ba; atomic weight, 136·8).—The metal barium has not yet been obtained in the coherent condition, only in metallic powder. The spectrum of barium contains a number of green lines, by which the presence of minute traces of this metal may always be detected. Its compound with oxygen is called *baryta* (BaO).

Carbonate of baryta is found in many parts of England. The same earth is also found in combination with sulphuric acid, forming heavy spar. When finely powdered, on account of its great weight, it is employed to adulterate white lead. It is also used to give a fictitious *body* to calicoes and paper.

Baryta is distinguished among the other earths by being a violent poison. All its compounds also are poisonous, except the sulphate (heavy spar). It yields the only white for water-painting that never changes, and it may be mixed with any other colour without injury. Various oil colours are now extensively manufactured from it by dyeing it the shade required. Almost all the Brunswick greens are thus obtained. Baryta differs remarkably from lime in being very soluble in boiling water, from which it crystallizes on cooling.

STRONTIUM (Sr; atomic weight, 87·2) is a yellowish white metal, with a specific gravity of 2·54. The spectrum of strontium exhibits a bright line in the blue, one in the orange, and six less distinct ones in the red portion of the spectrum. Strontium combines with oxygen to form the oxide called *strontia* (SrO).

Carbonate of strontia was first found in the lead mine of Strontian in Argyleshire, but the sulphate is now found plentifully in several other places. Thus, near Bristol and Paris, it is employed as road metal, and in the state of Pennsylvania, United States of America, it occurs in great abundance. The earth which forms its base is not poisonous like baryta, but it resembles that earth in being very soluble in boiling water, and in crystallizing on cooling. Its distinguishing property is the red colour which it imparts to flame, and hence its use as an essential ingredient in the red fire of theatres. It has also been tried on a small scale in medicine.

Strontium nitrate, $Sr(NO_3)$, is principally of value in the composition of red fire, which consists of—

Red Fire.	Grains.	Green Fire.	Grains.
Dry strontium nitrate,	800	Dry barium nitrate, .	450
Sulphur, ...	225	Sulphur, ...	150
Potassium chlorate, .	200	Potassium chlorate, .	100
Lampblack, . . .	50	Lampblack, . . .	25

The strontium or barium salt, the sulphur, and the lampblack are finely powdered and intimately mixed, after which the potassium chlorate is added in rather coarse powder, and mixed with the other ingredients without rubbing, which might cause an explosion.

MAGNESIUM (Mg; atomic weight, 23·94; specific gravity, 1·74).—This metal exists in considerable quantities in mineral nature, especially associated with lime in magnesian limestone. It is an ingredient of talc, soapstone, potstone, asbestos, fossil cork, and several other minerals generally of a fibrous texture and silky lustre. Epsom salt is a well-known combination of it with sulphuric acid; and from this salt the earth is usually prepared for chemical purposes. Separated from its combinations it is a very white, soft, and light earth, does not slake like lime, and is almost insoluble in water.

Magnesium oxide, or *magnesia* (MgO), can easily be procured by subjecting the magnesia of the apothecary (which contains more than half its weight of carbonic acid) to a white heat; and this medicinal magnesia may again be procured by making a hot solution of Epsom salt and pouring into it a solution of carbonate of potash or soda; a double decomposition of the salt takes place, and the carbonate of magnesia which is formed is precipitated, while the alkaline sulphate remains in solution. The metal itself has only recently been prepared in quantity. It is usually obtained by heating magnesium chloride ($MgCl_2$) with metallic sodium, sodium chloride and metallic magnesium being formed. The metal is of a silver white colour, and fuses at a low red heat. When soft it can be rolled into wire, and with care may be cast like brass. When strongly heated in the air it takes fire and burns with a dazzling white light, forming its only oxide, magnesia. The magnesium light is rich in chemically active rays, and is therefore sometimes employed as a substitute for solar light in photography. It has been employed with success for photographing the interior of the pyramids, caverns, &c. Magnesium does not oxidize in dry air; it is slowly acted upon by cold water, and more rapidly by hot water; it rapidly dissolves in sulphuric and hydrochloric acids, evolving hydrogen.

Magnesium sulphate ($MgSO_4 + 7H_2O$) is a soluble substance known as Epsom salts, found in a spring at Epsom, Surrey, and containing seven atoms of water of crystallization. Magnesium sulphate is now largely made from dolomite by separating the lime with sulphuric acid.

Of these earths are composed all rocks, stones, gems, and soils that are found throughout, and constituting the globe. Some of these minerals contain but one earth; but minerals are found in which the earths are combined in different proportions by processes which produce that apparently endless variety of objects which mineral nature presents.

CHAPTER VIII.

CARBON—COAL—DIAMOND—GRAPHITE—PLUMBAGO—CARBON DIOXIDE—CARBON MONOXIDE—MARSH GAS—ACETYLENE—ETHENE—COAL GAS—COMBUSTION—GUNPOWDER—NITRO-GLYCERINE—NITRO-GLYCERINE MOLECULE.

CARBON (symbol, C; atomic weight, 11·97).—Carbon is not known to exist in the free state either as a gas or a liquid; as a solid it exists in three distinct forms, identical in their chemical relations, but having distinct physical properties. These "allotropic" forms of carbon, as they are called, are diamond, graphite or plumbago, and charcoal; these substances differ in hardness, colour, specific gravity, &c., but on combustion in air or oxygen they each yield exactly the same weight of the same substance, carbonic acid or carbon dioxide. The element carbon forms with oxygen, hydrogen, and nitrogen a series of more or less complicated compounds, which give rise to a separate branch of chemistry under the name of *organic chemistry*, or the chemistry of the carbon compounds. Carbon in its pure state is far from being plentifully distributed in the mineral kingdom. The only specimen is the diamond, the hardest substance which nature affords. Next in point of purity is graphite, a mineral very well known under the names of plumbago and blacklead. In this state carbon exists in considerable abundance, though the fine graphite of Cumberland is still an article of great value for blacklead pencils. In the next stage of purity carbon exists in vast abundance, forming the mineral so well known under the name of anthracite. The chemical constitution of this coal differs from graphite only in its having, in addition to a small and variable portion of iron, which is common to both minerals, a percentage of silica and alumina, which remains as residuum when the coal is burned.

In the United States of America anthracite exists in abundance. Pennsylvania alone could perhaps supply Europe with fuel for the next thousand years. In Scotland it is found in smaller patches, but more plentifully in Ireland, where it is known as Kilkenny coal, and in South Wales, where it is of importance as a fuel for the smelting of iron, both by hot and cold blast.

Anthracite differs from common pit-coal in containing no bitumen, and this is the reason of its burning without flame and smoke, and also of the difficulty there is in kindling it. Carbon is nevertheless the main constituent of common coal. Coke is this substance in about the same state of purity as it exists in anthracite, and is simply formed by exposing common pit-coal to ignition for some time out of contact of air. In the process, about a fourth of the weight is dissipated, and the spongy iron-black mass which remains is carbon, more or less pure, according to the quality of the coal from which it was made. Carbon may be obtained in a state still more nearly pure, and in considerable quantity. This is by the calcination of wood out of contact of air. To obtain the exclusion of the atmosphere, the wood is commonly subjected to ignition in close vessels: this allows of the volatile products being retained, and it is with a view to these that the operation is often more especially conducted. Or the wood may be made up in piles, and covered with loam to screen it from the atmosphere during ignition. This mode is still practised where the carbon is the only product in request. Such carbon is well known under the name of *charcoal*, as a black porous mass without taste or smell. Although very combustible in air, it can bear the highest heat of our furnaces without change, provided air be excluded; it is a bad conductor of heat, but conducts electricity well. When burned in air it unites with oxygen, and forms carbonic acid—the choke damp of the miner, the gas which constitutes the sprightliness of champagne, bottled ales, and soda water, and which has so often proved fatal in close apartments heated by charcoal fires.

By substituting hydrogen gas for the oxygen of the carbonic acid the compound produced is the gas so extensively manufactured for artificial illumination, known in chemistry as bicarburetted hydrogen, and popularly as coal-gas. By its combustion the two products formed are carbonic acid and water, the carbon uniting with one portion of the oxygen of the air and the hydrogen with another. When the combustion is incomplete, a quantity of the carbon is set free in the form of smoke.

Graphite, or *plumbago*, consists of nearly pure carbon with a trace of iron; it is found in various parts of Europe, and in large quantity in some parts of North America, especially in New Brunswick. It occurs in gneiss and mica slate, and their subordinate clay slates and limestones, in the form of veins, masses, and kidney-shaped disseminated pieces. The most precious deposit which has yet been discovered is in the transition slate at Borrowdale in Cumberland. The graphite which can be directly cut into leads for pencils being very limited in quantity, powdered graphite is obtained from coarse impure graphite purified by treating the graphite powder, previously mixed with $\frac{1}{14}$ of its weight of potassium chlorate, with two parts of concentrated sulphuric acid, heated in a water bath until the decomposition ceases. The acid is then removed by washing, leaving the pure graphite, when dried, in the form of a bulky and finely divided powder. This powder, when strongly compressed, forms a coherent mass, from which pencils and other articles are made. Graphite is employed for giving a protecting surface to grains of gunpowder, and also for polishing surfaces of ironwork. It is also used as a kind of lubricator in the delicate moving parts of pianoforte and organ actions. Graphite is produced in the manufacture of iron; it frequently separates from the molten pig-iron in the form of scales. The annexed table gives the alteration which vegetable fibre has undergone in passing into the various forms of coal:—

COMPOSITION OF FUELS, ASH BEING DEDUCTED.

Description.	Carbon per cent.	Hydrogen per cent.	Nitrogen and Oxygen per cent.
Woody Fibre, ...	52·65	5·25	42·10
Peat from the Shannon, .	60·02	5·88	34·10
Lignite from Cologne, . .	69·96	5·24	27·76
Earthy Coal from Dax, .	74·20	5·89	19·90
Wigan Cannel, ...	85·81	5·85	8·34
Newcastle Hartley, . . .	88·42	5·61	5·97
Welsh Anthracite, . . .	94·05	3·38	2·57

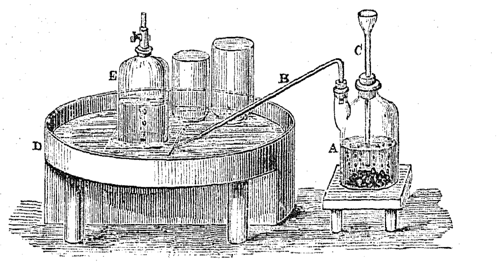
The *diamond* was first found to consist of pure carbon by Lavoisier, in 1776, by burning it in oxygen. Its specific gravity varies from 3·3 to 3·5. The mode in which the diamond has been formed is unknown; it cannot, however, have been produced at a high temperature, because when heated strongly in a medium that does not act chemically upon it, the diamond swells and is converted into a black mass resembling coke. The diamond is the only substance which is capable of cutting glass. Some other hard substances, it is true, scratch it, but none fairly cut it like the diamond. This peculiar property of the glazier's diamond is due to the peculiarity of its crystallization in rounded faces and curvilinear edges—the curvilinear edge adjoining the curved faces, entering as a wedge into the furrow opened up by itself, thus tending to separate the parts of the glass. For glass-cutting, those rough diamonds are always selected which are sharply crystallized, called technically diamond sparks; but cut diamonds are never used. In order that the crack, which causes the separation of the vitreous particles, may take place, the diamond must be held almost perpendicular to the surface of the glass. The depth to which the fissure caused by the glazier's diamond penetrates does not seem to exceed the two-hundredth part of an inch.

The structure of the diamond is lamellar, and therefore, notwithstanding its great hardness, it is brittle, and gives way readily in the line of its cleavage, affording a direct means of arriving at its primitive form, which is that of the regular octahedron (eight-sided solid). It possesses either single or double refraction, according to its crystalline form; and its refractive power on light is so great in comparison to its density (3·55) that Newton was long ago led to suppose that it consisted of inflammable matter.

The diamond, in common with several other minerals, becomes self-luminous by heating, and also by exposure to

the sun's light for a certain time. Exposure to the blue rays of the prismatic spectrum augments still more this property of shining in the dark. Besides its great mean refractive power (index 2·44), diamond possesses a high dispersive agency which enables it to throw out those varied and vivid colours for which it is so highly prized.

Carbon forms two compounds with oxygen—*carbon monoxide* (CO) and *carbon dioxide* (CO_2). *Carbon dioxide*, formerly and still commonly called *carbonic acid gas* (atomic weight, 43·89; density, 21·94), is always formed when carbon is burned in air or oxygen gas. It is easily prepared by treating marble, chalk, or other form of calcium carbonate with hydrochloric acid. Fragments of chalk are placed in the bottle, A, with enough water to cover the end of the



funnel tube, C, and hydrochloric acid is then added through the funnel until the gas is freely disengaged. The gas, passing by the tube, B, is collected in the vessel, E, placed over a pneumatic trough. The decomposition is—

Carbonate of Lime.		Hydrochloric Acid.		Carbon Dioxide.		Water.		Calcium Chloride.
$CaCo_3$	+	2HCl	=	CO_2	+	H_2O	+	$CaCl_2$.

Carbon dioxide occurs free in the air; the quantity, though relatively small—4 volumes in 10,000 of air—in the aggregate is very large, being upwards of 3,000,000,000 tons in weight. Carbon dioxide consists, in 100 parts, of carbon 27·27 and oxygen 72·23. If 27·27 is divided by the combining weight of carbon, and 72·23 by the combining weight of oxygen, $\frac{27·27}{11·97}=2·278$, and $\frac{72·23}{15·96}=4·557$; or the relation between the number of atoms of carbon to the atoms of oxygen is as 1 to 2, so that the formula of carbon dioxide is CO_2; and as 44 parts by weight of carbon dioxide occupy a volume equal to that occupied by 2 parts by weight of hydrogen, and contain 32 parts by weight of oxygen, which also occupies a volume equal to that of 2 parts of hydrogen, carbon dioxide contains its own volume of oxygen, and the volume of carbon dioxide formed is precisely equal to that of the oxygen used in its formation.

Carbon monoxide (CO; atomic weight, 27·93; density, 13·96). This carbonic oxide gas is formed when carbon is burnt with a limited supply of oxygen. It may be often observed in the ordinary red-hot coal fire. The oxygen of the air entering at the bottom of the grate, combines with the carbon of the coal, forming carbon dioxide (CO_2); this gas, passing upwards over the red-hot coals, parts with half its oxygen to the red-hot carbon, thus $CO_2+C=2CO$. This carbon monoxide on issuing at the top of the fire meets with atmospheric oxygen, with which it at once combines, burning with a lambent blue flame, and re-forming carbon dioxide. Carbon monoxide gas in a pure state can be obtained by passing a slow current of carbon dioxide over fragments of charcoal heated to redness in a tube by means of a furnace. It is a colourless, tasteless gas, and acts as a strong poison.

The compounds of carbon with *hydrogen* are very numerous, and they are known in the gaseous, liquid, and solid forms. Some of the more simple compounds are here described.

Methyl hydride, marsh gas, or *carburetted hydrogen* (CH_4; atomic weight, 15·97; density, 7·98). This is a colourless, tasteless, inodorous gas, which liquefies under great pressure and at a low temperature. It is abundantly disengaged in coal mines from the fresh-cut surfaces of coal, and from apertures in the coal termed "blowers," which emit a copious stream of pent-up gas for a length of time, known under the name of *fire-damp*. It also occurs in stagnant pools, being produced by the decomposition of dead leaves and other vegetable matter, whence its name of marsh gas. It may be prepared by heating sodium acetate with caustic soda; the reaction is as follows:—

Sodium Acetate.		Sodium Hydroxide.		Marsh Gas.		Sodium Carbonate.
$NaC_2H_3O_2$	+	NaHO	=	CH_4	+	Na_2CO_3.

Marsh gas burns with a bluish-yellow flame, forming carbon dioxide and water. If mixed with ten times its volume of air, or twice its volume of oxygen, it ignites with a sudden and violent explosion on the application of a light, and hence the great damage produced in coal mines.

Acetylene (C_2H_2) is formed by the union of carbon and hydrogen at a very high temperature. The carbon terminals of a powerful voltaic battery are employed, and brought into contact in an atmosphere of hydrogen. A direct union of carbon and hydrogen takes place at the high temperature evolved, and acetylene is formed. It is a colourless gas, burns with a bright flame, and possesses a peculiar and unpleasant odour. Acetylene is produced by incomplete combustion, and its smell is noticed when a candle burns with a smoky flame. Acetylene combines with copper and silver; and the compounds readily undergo explosive decomposition. This gas unites directly with hydrogen, forming *ethene* ($C_2H_2+H_2=C_2H_4$).

Ethene or *olefiant gas* (C_2H_4; atomic weight, 27·94; density, 13·97). This gas is an important constituent of coal gas, and is obtained on the destructive distillation of coal. The gas is colourless, and possesses a sweetish taste, with a faint odour of garlic. It burns with a brilliant white light. When mixed with three times its bulk of oxygen and fired, it explodes with extreme violence. Chlorine acts upon ethene in a remarkable manner. When the two bodies are mixed, they combine in equal volumes, and form a heavy oily liquid ($C_2H_4Cl_2$). From this peculiarity the name of olefiant gas is obtained.

Coal Gas, the ordinary gas used for illuminating and heating purposes, is not a simple chemical compound, but is composed of many distinct substances. In order to obtain coal gas of good quality, some highly bitumenized coal, as cannel, is heated in a closed retort. The volatile bodies thus formed are collected, while a residue of impure carbon is left behind in the retort. The volatile products are tar, ammonia, water, and gas. The tar contains a variety of substances, from some of which aniline colours are produced; the ammonia obtained from the nitrogen in the coal is utilized in the production of ammoniacal salts. The gas is very impure as it comes off, containing both substances useful for heating and illuminating purposes, and others which are impurities and must be removed. The luminous gases are olefiant and other hydrocarbons, mingled with gases that burn with a non-luminous flame, as hydrogen, carbonic oxide, and marsh gas. The impurities consist of carbon dioxide, sulphuretted hydrogen, and the vapour of carbon disulphide. These are removed from the gas by a system of purification.

The illuminating power of coal gas is ascertained by comparing the light from the gas burning at the rate of 5 cubic feet per hour, with that of a sperm candle consuming 120 grains per hour. Thus cannel gas is equal to 34·4 candles, and coal gas equal to 13 candles.

COMPOSITION OF COAL GAS, 100 VOLUMES.

	Illuminating Power in Candles.	Hydrogen, H.	Marsh Gas, CH_4.	Heavy Hydrocarbons, C_nH_{2n}.	Carbonic Oxide, CO.	Nitrogen, Oxygen, Carbonic Acid.
Cannel gas, .	34·4	25·82	51·20	13·06	7·85	2·07
Coal gas, . .	13·0	47·60	41·53	3·05	7·82	—

When a solid body is heated to a certain point it emits light, the character of which is determined by the temperature. (See NAT. PHILOSOPHY, *Heat*.) A rod of platinum raised to

a certain temperature becomes red-hot and emits a red light; at a higher degree of heat the light becomes more intense and whiter, and at the highest temperature, as when lime is subjected to the flame of the oxyhydrogen blowpipe, the light is exceedingly powerful. Substances in these states are said to be *ignited* or *incandescent*. When charcoal is subjected to a high temperature, it gradually wastes away until it disappears; the charcoal *burns*, and its heat is maintained by that which is evolved in the act of union with the oxygen in the air. This is what is termed *combustion*. In all ordinary cases of combustion the materials employed for the economical production of heat and light consist chiefly of carbon, or carbon conjointly, with a certain proportion of hydrogen and oxygen; the heat is the result of chemical union, and the light of extreme temperature. Combustion is more rapid as larger quantities of air are introduced into the burning mass, and the intensity of the heat rises in the same ratio, the heat evolved being fixed and definite for the same amount of chemical action. The ordinary smith's bellows, and the blast of the iron furnaces, are employed on this principle. Solids and liquids, as molten metal, when sufficiently heated emit light; the same power is exhibited by gaseous bodies, but the temperature necessary to render a gas luminous is much greater, and constitutes *flame*, the temperature of which generally exceeds that of the white heat of solid bodies. The illuminating power of a flame is largely increased by the presence of solid matter. The flame of hydrogen is scarcely visible in daylight, but in a dusty atmosphere, by heating to intense whiteness the floating particles with which it comes into contact, its luminosity is greatly increased. It is, however, possible to produce very brilliant flames in which no solid particles are present. The flame from the "Holmes signal light" is of immense brilliancy and contains no solid particles (phosphuretted hydrogen and oxygen); the combustion of a mixture of nitrogen dioxide and carbon bisulphide also produces a dazzling white light without any separation of solid matter. The conditions most essential to luminosity in a flame are a high temperature and the presence of gases or vapours of considerable density. The relation between the luminosity of a flame and the vapour densities of its constituents is shown in the annexed table, hydrogen being taken as unity.

RELATIVE DENSITIES OF GASES AND VAPOURS.

Hydrogen, ...	1	Arsenious chloride, .	90·75
Water, ...	9	Phosphoric oxide, .	142
Hydrochloric acid, .	18·25	Metallic arsenic, . .	150
Carbon dioxide, . .	22	Arsenious oxide, . .	198
Sulphur dioxide, . .	32		

The brightest flames are therefore those which contain the densest vapours. The luminosity of a flame is increased by a denser surrounding gaseous medium, and diminished by rarefaction; thus, candles burn with much less light upon the summit of Mont Blanc than in the denser medium in the valley below, the rate of combustion being about the same in each case. The igniting point, or temperature at which combustion commences, is very different with different substances: phosphorus will inflame in the hand; sulphur requires a temperature above 100° C.; charcoal must be heated to redness. Gaseous bodies exhibit the same differences: hydrogen is inflamed by a red-hot wire; light carburetted hydrogen requires a white heat. When flame is cooled below the temperature at which rapid oxidation of the combustible gas occurs, it is immediately extinguished. The "Davy safety lamp" depends on this principle.

Combustion may, however, take place without atmospheric air, the oxygen necessary being obtained from some associated substance, as there are many materials in which a large amount of oxygen is so loosely combined, or in which the oxygen-atoms are held in combination by such a feeble force, that they provide oxygen to the combustible as readily as the atmosphere, and in a much more condensed form. Two of these substances are *potassic nitrate* or *nitre* (KNO_3), and *potassic chlorate* or *chlorate of potash* ($KClO_3$); an ounce of this salt contains about 1·7 gallon of oxygen. If one-third of an ounce of powdered sugar be well mixed with an ounce of chlorate of potash, every particle of the sugar, which is a combustible substance, is in close proximity to grains of chlorate of potash containing sufficient oxygen to consume the whole. Both materials being in a solid condition, their molecules are confined and unable to exercise that degree of molecular activity necessary to produce chemical change. This molecular activity may be excited by heat, which is at once evolved by touching the mixture with a drop of sulphuric acid; combustion then immediately takes place, the necessary oxygen having been derived from the chlorate of potash instead of from the atmosphere; it therefore becomes possible to inclose in a confined space, as a gun barrel, all the conditions of combustion. This is the simple theory of gunpowder, which consists of an intimate mixture of two substances, *nitre* and *charcoal*, with a small amount of sulphur added to facilitate the ignition of the charcoal. In the general decomposition which occurs when gunpowder is fired, the oxygen of the nitre combines with the charcoal forming carbonic acid and carbonic oxide, while the nitrogen is liberated, and the sulphur combines with the potassium, and the great explosive power is due to the violent evolution of large quantities of gas, and a rapid rise in temperature, causing an increase in bulk sudden enough to cause what is termed an *explosion*. In practice it is found that the best gunpowder is that which contains nearly two molecules of nitre to one atom of sulphur and three of carbon. In the manufacture of gunpowder, the materials are first reduced to a very fine powder, and then intimately mixed together. Afterwards by great pressure the mass is converted into a firm hard cake, which is afterwards broken up into grains of different sizes, varying from the size of a walnut to that of a grain of millet seed. The composition of musketry powder in general use is given annexed.

	English and Austrian.	Prussian.	Chinese.	French.
Nitre, ...	75	75·0	75·7	75·0
Charcoal, . . .	15	13·5	14·4	12·5
Sulphur, ...	10	11·5	9·9	12·5
	100	100·0	100·0	100·0

The gas evolved on the ignition of powder at the ordinary pressure of the atmosphere, is about 300 times the volume of the powder used, which, when confined in the space previously filled with the powder, would exert a pressure of about 2 tons on a square inch. As the powder burns rapidly this pressure is suddenly applied and produces the effect of an immensely heavy blow. In the chamber of a gun the ball usually yields before the breech, and is projected with great velocity from the mouth of the gun; fearful accidents sometimes occur when the ball has been too tightly wedged, or when the metal of the gun breech is too weak. The vast number of gas molecules suddenly set free in the chamber of the gun moving with all the velocity which great energy has imparted, rush against the ball, and when it starts, impart to it their moving power, until it acquires the velocity with which it leaves the gun. The effect is due to the accumulative force of small impulses, the power exerted by a single molecule being as nothing, but the accumulated effect of millions on millions of these individual impulses being enormous.

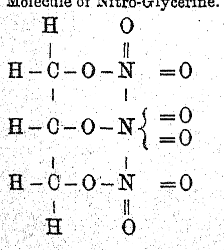
There are various other chemical compounds which form explosive agents of more potent energy than gunpowder, such as gun-cotton, nitro-glycerine, dynamite, tonite, &c.

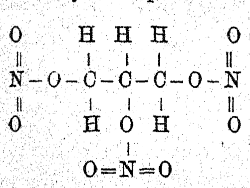
Glycerine ($C_3H_8O_3$), largely employed as a cosmetic, is a clear, oily, sweet-tasting liquid, obtained in large quantities as a secondary product of the manufacture of soap and candles from common fats, and it bears the same relation to nitro-glycerine as caustic potash does to saltpetre. When nitric acid is poured into a solution of caustic potash, crystals of saltpetre are formed, and when glycerine in a very fine stream is poured into very strong nitric acid, rendered more active by being mixed with sulphuric acid, *nitro-glycerine* is formed. Apparently no change has taken place, as nitro-

glycerine resembles very closely in appearance glycerine itself, and is a colourless, oily fluid, the reddish-yellow colour of the commercial article being due to impurities. When the chemical change is completed, the nitro-glycerine is very carefully washed with water, removing all the adhering acid, as very many of the accidents that have happened with nitro-glycerine have arisen from the use of an impure article. It is usual to explode nitro-glycerine, not by the direct application of heat, but by a sudden and violent concussion, obtained by firing, in contact with it, a fuse containing some fulminating compound.

The handling of liquid nitro-glycerine is in practice found inconvenient. It is therefore usual to mix with it some inert and impalpable powder, and to mixtures of this kind the names *dynamite* and *dualine* have been given. The powder merely acts as a sponge. Nitro-glycerine produces peculiar effects on explosion. When gunpowder is employed it is necessary to confine it; thus for blasting, a hole is prepared in the rock, and it is confined by what is termed tamping. With nitro-glycerine this is unnecessary; it may be placed in the drill holes and a little water only poured on the top. As an agent for blasting it is greatly superior to gunpowder; but while it has such vast rending power, it has no value whatever as a projectile agent, for if exploded in a gun it would burst the breach before expelling the ball. The chemical action in the explosion of nitro-glycerine is very similar to that of the combustion of gunpowder. In both cases large volumes of gas are produced, and there is the liberation of a great amount of energy, which imparts to the gas molecules vast moving power, and in both the process consists mainly in the union of carbon and hydrogen atoms with oxygen, yielding the same products. In gunpowder, however, the carbon and oxygen atoms are in different molecules lying side by side in the same grains; in nitro-glycerine they are in different parts of the same molecule. In chemistry every molecule is regarded as having a definite structure; it not only consists of a specific kind, and fixed number of atoms, but these atoms are arranged and grouped together in some definite order, which it is the great object of modern chemistry to discover. In some instances the grouping of the atoms in the molecules of substances appears to have been ascertained with tolerable certainty. Thus chemistry has ascertained the grouping of the atoms in a molecule of nitro-glycerine, $C_3H_5N_3O_9$, which may be represented graphically by the diagram, the letter signifying single atoms, and the lines between them merely showing how the atoms are severally united. Thus, the three atoms of carbon are united together by a certain force; to these are directly united five atoms of hydrogen, and then to each of these carbon atoms is also bound the atomic group—$O-N\left\{\begin{matrix}=O\\=O\end{matrix}\right.$, the four atoms of this group having a definite arrangement among themselves. The same system upon which the atoms are united with one another may be shown by a second diagram; the one diagram and the other mean to the chemist precisely the same atomic arrangement. That the atoms of the molecule of nitro-glycerine are grouped as indicated, is shown by the symbol, $C_3H_5N_3O_9$. When the substance explodes, the oxygen atoms at one end of the molecule rush for the atoms of carbon and hydrogen at the other side, and the molecule is broken up. The chemical action is therefore nearly the same as in the burning of gunpowder, the difference being that while in the powder the carbon and oxygen atoms belong to different molecules, in nitro-glycerine they belong to the same molecule. In both cases the carbon burns, but in the nitro-glycerine the combustion is *within* the molecule. This is a most important difference, and shows itself in the effects of the explosion. In gunpowder the grains of charcoal and nitre have a sensible magnitude, and consist each of many million molecules. The chemical union of the oxygen of the nitre with the carbon atoms of the charcoal can take place only on the surface of charcoal grains, and the first layer of molecules must be consumed before the second can be reached, and so on. The process therefore takes a sensible time, although very rapid. In the nitro-glycerine, the two sets of atoms are in one and the same molecule, and the internal combustion is essentially instantaneous. This element of time explains a great part of the difference in the effect of the two explosions, and a part is also due to the fact that nitro-glycerine yields fully 900 times its volume of gas, while with gunpowder the volume is only about 300 times that of the solid grains. The effect of the instantaneous development of this large volume of gas, which becomes at once a part of the atmosphere, in an explosion of nitro-glycerine, is the equivalent of a blow by the atmosphere against the body to be shattered, or as the air is the larger mass, a blow by the body against the air, which acts as an anvil against which a rock can be split. This is easily understood by considering the resistance offered to any body moving with great velocity against the air. At 12 miles a minute (or about the velocity of sound) a wooden board, say a yard square, would be broken into splinters; and at a velocity of about 1200 miles a minute (about the velocity of the earth in its orbit) the air at the surface of the earth would present a barrier against which the hardest rocks might be shivered into fragments. This effect is often seen when meteoric masses, moving with these planetary velocities, penetrate our atmosphere as meteors: the explosions which have been witnessed are simply the effect of the concussion against the aeriform anvil at the point where the meteoric mass enters. In the case of nitro-glycerine, the body strikes the atmosphere with such a velocity that it has the effect of a solid mass, and the substance is shivered by the blow.

Molecule of Nitro-Glycerine.





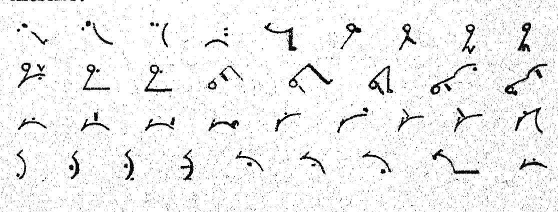
SHORTHAND.—CHAPTER IV.

THE ASPIRATE—CONSONANTAL COMBINATIONS—INITIAL HOOKS.

The student will have noticed that the stroke for *h* may be written either up, as , or down, as , whichever may be found most convenient in securing the joining of it with any other letters. So frequently, however, does the aspirate occur that some more readily formed signs are found necessary; hence the aspirate *h* is sometimes written by a small dot prefixed to the vowel-sign, thus had, have, but still more frequently by downward or upward, as hay, honey.

Before *m*, upward *l*, *s*, *z*, and downstroke *r*, the downward *h* may be shortened to a tick, thus *hm*, *hl*, *hs*, *hz*, *hr*, *hmp;* but this tick cannot be used before *m* or *l* when a first-place vowel follows *h*.

The following exercise, which should be slowly and carefully written out at first, will illustrate the various uses of the aspirate *h*. After due mastery of the form and relations of the signs, speed may be made an object in writing out the exercise:—



The stroke *h* may be written intermediately—that is, between two consonants; but in this case care must be taken that the circle is on the same side as that of the stroke part of the letter, as if it stood alone: unholy, not ; behave, not ; Jehovah, not . The reason for this will be apparent when the student has made some

advancement in the knowledge and practice of phonographic writing.

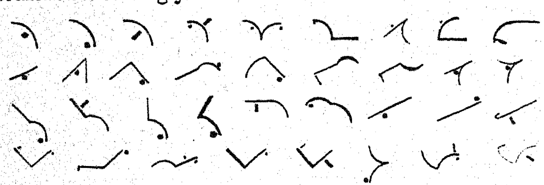
The learner may now proceed to study the rules which (1) regulate the use of the signs for the downward *r* and *l*, (2) direct us in the employment of the double letters, and (3) inform us what is required of us that we may be able to adopt the abbreviations provided for the shortening of words.

When *r* is the consonant which first occurs in the spelling of a word, it is written *downwards* if preceded by a vowel, and *upwards* if it is not preceded by a vowel; as air, ray, arm, rate.

When *r* is the last consonant which occurs in a word, it is written *downwards* when it is the final sound, and *upwards* if a vowel follows it; as mar, marry. The upward *r* is always written after a straight upstroke, thus rare, wore. There are a few words in which faithful adherence to this rule would practically result in the production of inconvenient outlines, as earth. In such and similar cases the upward *r* is used.

Initial *l* before either of the horizontal consonants *k*, *g*, *m*, *n*, *ng* is written *upward* if it is the first consonantal sound in the word, and *downward* if a vowel precedes it; as like, alike; lone, alone.

Final *l* (after *f*, *v*, and the upstrokes *r*, *w*, *y*, *h*) is written *upward* if it is followed by a vowel, and *downward* if it is the last consonantal sound in the word. After *n*, *l* is generally written downward. When *l* is written with the downstroke, or *sh* with the upstroke, the vowels' places require to be reckoned accordingly.



The student has had presented to him, on page 180, the forms of the double letters in the phonographic alphabet, but it may be useful here, as an aid to his further progress as an intelligent learner, to explain their forms and to try to make their uses more clearly understood.

The first double letter occurring in the alphabetic arrangement there adopted is *wh*. It is used in such words as where, whip, whine. There are several words, however, which contain the letters *wh* but do not retain the sound, as whom, whose, whoop. Now as phonography is "writing by sound," they should be written thus, whom, whose, whoop.

The combinations *kw*, *gw* are of very frequent occurrence, and may be used either initially or medially; as quality, quantity, liquid, anguish, aqueducts.

The consonantal sign *mp* or *mb* is joined to other consonants and vocalized to form words; thus, camp, jump, lump.

The termination *lr* is not used so frequently, but it occurs in words like scholar, ruler, feeler.

The complex articulation which is denoted by *rch* or *rj* is generally used terminally, occurs rarely, and only in a few words initially. It will be at once seen that it is really a combination of *r* and *ch* or *r* and *j*; thus, perch, instead of ; purge, instead of . Initially it is used in words like arch, archer, archery.

The sign *wl* is used frequently in monosyllabic words, as will, well; and also in words like welfare, Willy. The hook is made larger to represent *wh*, and is used in words like wheel, whale. It is necessary to remember, in vocalizing the *wl*, *whl*, that the small hook adds *w* and the large hook *wh* to *l*, and that a vowel is either read close before or close after the consonant against which it is written.

We now come to consider the first principles of abbreviation in the phonographic art. Of these let us first explain initial hooks.

A small hook on the *left-hand* side of a straight and inside a curved consonant adds *r;* as *pr*, *tr*, *fr*, *mr;* on the *right-hand* side the hook adds *l;* as *pl*, *chl*, *kl*. As it would be inconvenient to add a hook on the outside of curved consonants, *l* is added to these by a larger hook; as *fl*, *ml*, *nl*.

For convenience in effecting joinings, *fr*, *vr*, *thr* have duplicate signs; thus, *fr*, *vr*, *thr*. The reason for this is that *rr* and *rchr* are not required, and *sr* is represented by and

These combinations, when we speak them and keep their sound simultaneously before our minds, should not be named by pronouncing the letters which compose them, but as if they formed a word; as *per*, not *pee ar;* *tel*, not *tee el.*

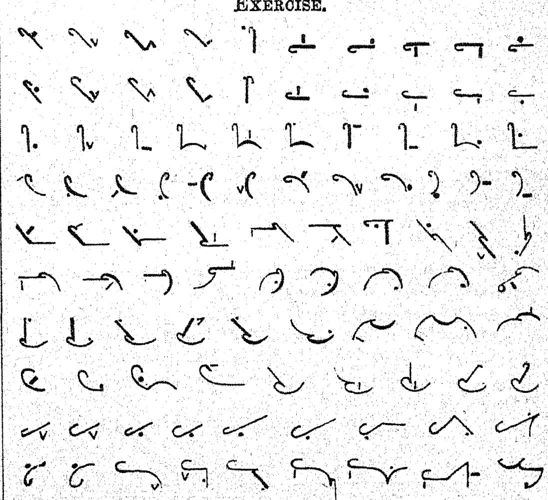
We supply below a list of all the combinations of letters which require the use of initial hooks. These should be carefully written out, and after that has been successfully done the exercise which follows it ought be copied over and over again. The exercise should not be regarded as effectively performed if done without writing the word represented by the characters immediately and directly underneath them. It requires to be diligently borne in mind, as an interpretative help, that a vowel before a hooked letter is read before *both* letters; as offer, other; and that one placed on the right-hand side is read after both; as ply, pry, grow.

INITIAL HOOKS.

Initial Hook, adding R.	*Initial Hook, adding L.*
pr, br; tr, dr; chr, jr; kr, gr.	pl, bl; tl, dl; chl, jl; kl, gl.
A small hook adds R to curves.	*A large hook adds L to curves.*
fr, vr; thr, *thr*; shr, zhr.	fl, vl; thl, *thl*; shl, (down) shl. (up)
mr, mpr *or* mbr.	ml, nl.

nr, ngr (ŋgr), *or* nkr (ŋkr).

EXERCISE.



It will form a beneficial extra exercise to write down a umber of words involving these letters in their orthography (or actual spelling), and then, by the application of the foregoing instructions, reduce them to phonographic expression.

MUSIC.—CHAPTER IV.

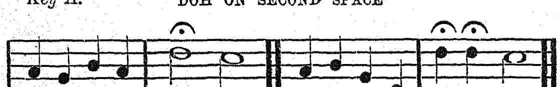
SECTION I.—MUSICAL SCALE LIMITED—NEW TONES, FAH AND LAH—MENTAL EFFECTS—STEPS OF THE SCALE—ILLUSTRATIVE PIECES.

A WELL-KNOWN publisher, desirous of having a favourite hymn set to music, applied to the late Frances Ridley Havergal. Almost by return of post, he received the hymn, set to a tune well fitted to secure popularity. It was found, however, on examination that one part of the air bore a striking resemblance to—was almost, indeed, note for note identical with—a section of a popular ballad. This similarity was pointed out to Miss Havergal, who, without the slightest alteration, returned it, with a remark to this effect—considering that we have only a scale of seven notes to work upon, the wonder is, not that there should be an occasional likeness, but that we should, from what appears such slender resources, be able to produce melodies so many, so beautiful, so distinct, and in such great variety.

With five of the seven notes thus spoken of by Miss Havergal the student is already acquainted, and it is now time to direct attention to the two which remain. These are called Fah and Lah, and are found, the lower between Me and Soh, and the upper between Soh and Te (see Modulator, p. 175). As in the case of the tones already studied, the greatest help to the learner, in becoming acquainted with those that are new, is to be found in the effect which each produces on the mind when taken in relation to the other tones of the scale. This has been called the mental effect of the tones in key. When the tone Fah is sung slowly it suggests to the hearer a solemn and rather gloomy idea, with a pleading earnestness to be found in no other tone. It would be well for the student to try to realize this, while singing the following.

Examples of the effect of Fah rather high in pitch—

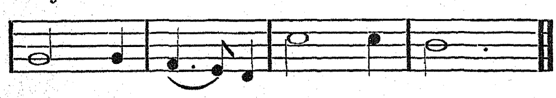
Key A. DOH ON SECOND SPACE



| d :t, | r :d | f :— | m :— || d :r | t, :s, | f :f | m :— ||

Or thus in the opening of Mozart's Twelfth Mass—

Key G. DOH ON SECOND LINE.

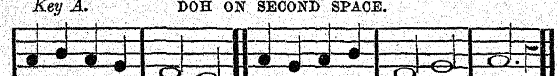


| d :— :d | t, :— .l, :s, | f :— :f | m :— :— ||

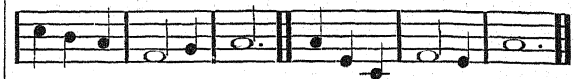
It should be observed that Fah is placed very near the tone Me, and just as the tone Te manifests a constant desire to be resolved on Doh (p. 269), so Fah, if sounded for any length of time, shows a decided tendency to fall to the tone Me. These (*i.e.* Te and Fah) may be described as leaning tones, with a strong bias to go in contrary directions: the one upward to Doh, the other downward to Me.

The tone Lah, standing almost midway between Soh and Te, has been spoken of as the sorrowful or weeping tone. It is quite exceptional in the expression it gives to feeling and tenderness. This also is a leaning tone, but like Ray does not, as a rule, so decidedly indicate the direction in which it wishes to proceed as Te and Fah do, being, as it were, content that the voice should pass either upward to Te, or downward to Soh.

Examples of the effect of Lah rather low in pitch—

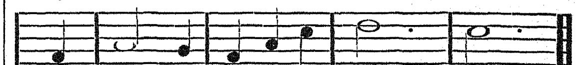
Key A. DOH ON SECOND SPACE.

| d :r | d :t, | l, :— | s, :— || d :t, | d :r | l, :— | t, :— | d :— | — : ||

The same, in three-pulse measure—



| m :r :d | l, :— :t, | d :— :— || d :s, :m, | l, :— :s, | d :— :— ||

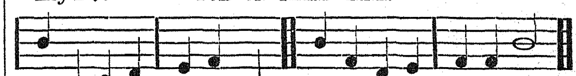
Examples of the effect of Lah high in pitch—

Key F. DOH ON FIRST SPACE.

| :d | m :— :r | d :m :s | l :— :— | s :— :— ||
Last night there were four Ma - ries.

| d :m :d | s :— :m | l :— :— | s :— :— ||

Frequently at the close of a tune, or section of a tune, Fah is heard in the bass or lower part of the harmony, not falling downward to Me, but marching in stately fashion upward to Soh; *e.g.*—

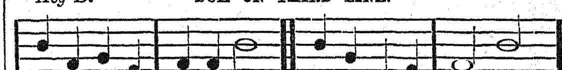
Key B♭. DOH ON THIRD LINE.



| d :d, | r, :m, | f, :s, | d, :— || d :s, | m, :f, | s, :s, | d :— ||

In this connection Fah is often combined with Lah.

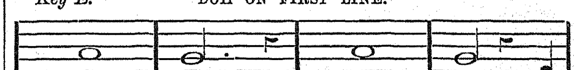
Key B. DOH ON THIRD LINE.



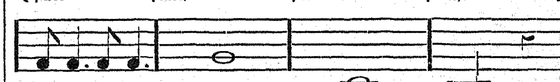
| d :s, | l, :f, | s, :s, | d :— || d :l, | m, :f, | s, :— | d :— ||

This similarity of contrast, if we may so speak, of Fah and Lah is thus brought out in the song "Too Late"—

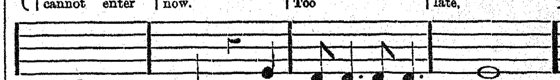
Key E. DOH ON FIRST LINE.



| f :— | — :— | m :— | — : | f :— | — :— | m :— | :d |
Too late, too late, Ye



| r.r :— | r.r :— | m :— | — :— | l, :— | — :— | s, :— | — : |
cannot enter now. Too late,



| l, :— | — :— | s, :— | :d | t,.t, :— | t,.t, :— | d :— | — :— ||
too late, Ye cannot enter now.

These different tones, viz. a key-tone (Doh), with its six related tones, are collectively termed a *scale;* which is thus made up of (1) three strong tones—Doh, Soh, and Me; and (2) four leaning or expectant tones—Ray, Fah, Lah, and Te. The two which show the greatest expectant tendency are Te and Fah. A glance at the Modulator will show that Te and Fah are tones really more closely related to those against which they lean than are the others. All scale tones stand at certain distances in pitch above or below each other. Although not mathematically correct it is found sufficiently so for practical purposes, to say that from Doh to Ray is a full step, or (as it is more frequently termed) a full tone; from Ray to Me another full tone; from Me to Fah a semi-

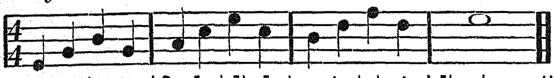
tone (*i.e.* half a tone); from Fah to Soh, Soh to Lah, and Lah to Te are each full tones; and from Te to Doh a semitone. The scale, therefore, consists of five full tones and two semitones; and going above or below these, we simply repeat them at a different pitch.

In scientific treatises Fah, the fourth of the scale, is called the *subdominant;* Lah, the sixth tone above Doh, is called the *submediant;* and these two tones, with Doh added—Fah, Lah, Doh—give us what is known as the chord of the subdominant. We now have ready for use the three chief chords employed in music—viz. Doh, the *tonic* chord (p. 178); Soh, the *dominant* chord (p. 269); and Fah, the *subdominant* chord. These three chords comprise all the notes of the scale.

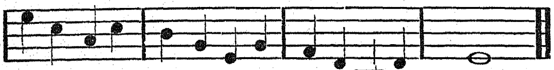
The student will now be prepared to practise the following exercises:—

Exercise 59.—DOH ON FIRST LINE.

Key E. J. S.



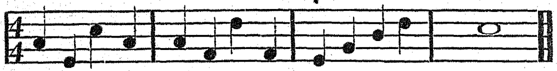
| d :m | s :m | f :l | d' :l | s :t | r' :t | d' :— | — :— ||
Ah - - - - - - - - - - - - - -



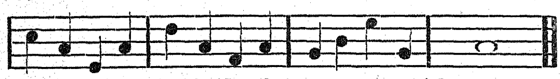
| d' :l | f :l | s :m | d :m | r :t, | s, :t, | d :— | — :— ||
Ah - - - - - - - - - - - - - -

Exercise 60.—DOH ON SECOND SPACE.

Key A. J. S.



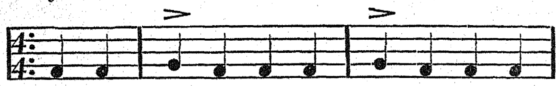
| d :s, | m :d | d :l, | f :l, | s, :t, | r :f | m :— | — :— ||
Ah - - - - - - - - - - - - - -

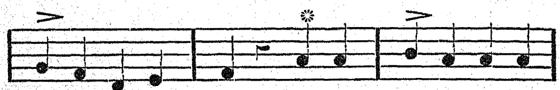


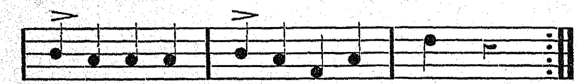
| m :d | s, :d | f :d | l, :d | t, :r | s :t, | d :— | — :— ||
Ah - - - - - - - - - - - - - -

Exercise 61.—ROUND IN TWO PARTS—DOH ON SPACE UNDERNEATH LOWEST LINE.

Key D. T. F. S.



| m :m | f :m | m :m | f :m | m :m |
If the weath-er keeps so storm - y, and the

| f :m | d :r | m : | s :s | l :s | s :s |
rain comes down like that, I shall nev - er have the

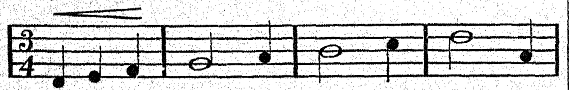


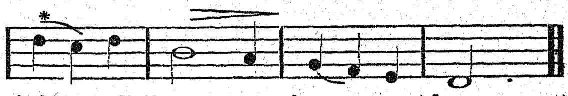
D.C.

| l :s | s :s | l :s | m :s | d' : ||
priv - i - lege of wear - ing my new hat.

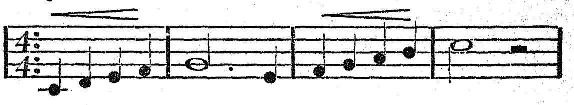
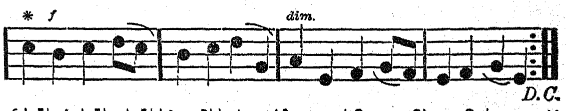
Exercise 62.—ROUND IN TWO PARTS—DOH ON SPACE UNDERNEATH LOWEST LINE.

Key D.



| d :r :m | f :— :s | l :— :t | d' :— :s |
Who sows good seed in fruit - ful loam, Shall

| d' :t :d' | l :— :s | f :m :r | d :— :— ||
bear with joy the har - vest home.

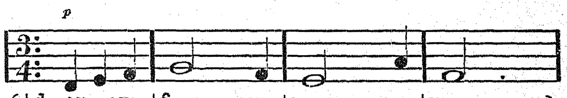
Exercise 63.—ROUND IN TWO PARTS—DOH ON FIRST LEDGER LINE BELOW.

Key C. J. SNEDDON.

| d :r | m :f | s :— | — :m | f :s | l :t | d' :— | : |
Let us mer-ry be. Fill all our hearts with glee.

D.C.

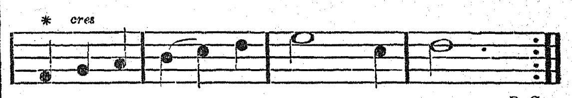
| d' :t | d' :r'.d' | t :d' | r' :s | l :m | f :s.f | m :f | s :m ||
Hearts and voi - ces all a - gree, Hearts and voi - ces all a - gree.

Exercise 64.—ROUND IN TWO PARTS—DOH ON SPACE BENEATH LOWEST LINE.

Key D. J. SNEDDON.



| d :r :m | f :— :m | r :— :s | m :— :— |
Sha - dows now dim our fee - ble sight,



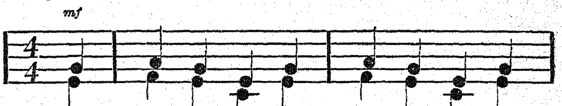
D.C.

| m :f :s | l :t :d' | r' :— :t | d' :— :— ||
All will be clear in Heav'ns pure light.

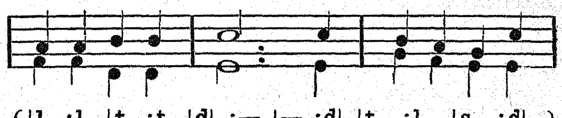
A solo is a piece to be performed by a single voice; a duet is a musical composition for two voices (or instruments); trio for three; quartet for four; quintet for five; sextet for six.

Exercise 65.—DUET—DOH ON FIRST LEDGER LINE BELOW.

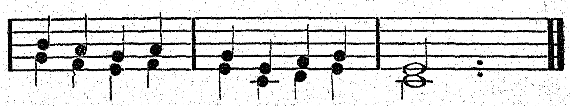
Key C. T. F. S.



| :s | l :s | m :s | l :s | m :s |
| :m | f :m | d :m | f :m | d :m |
1. O sweet to me the gen - tle spring, When
2. The plough-man drives his shin - ing share A -



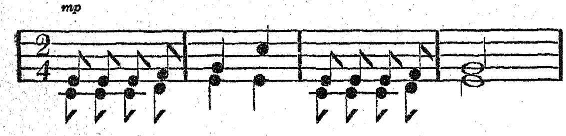
| l :l | t :t | d' :— | — :d' | t :l | s :d' |
| f :f | r :r | m :— | — :m | s :f | m :m |
earth is rob'd in flow'rs, And beau - ti - ful the
cross the mel - low lea, And lays the fur - row



| t :l | s :l | s :m | f :s | m :— | — ||
| s :f | m :f | m :d | r :m | d :— | — ||
sum - mer time. With all its leaf - y bow'rs,
broad and fair, As waves up - on the sea.

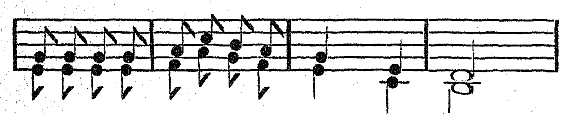
Exercise 66.—DUET—DOH ON FIRST LEDGER LINE BELOW.

Key C. THE DAISY. T. F. S.

mp

m .m :m .f | s :d^1 | m .m :m .f | s :—

d .d :d .r | m :m | d .d :d .r | m :—

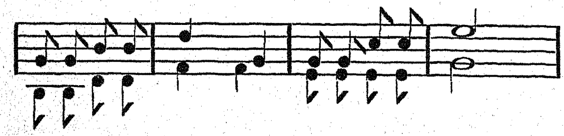
1. In the ear-ly spring time, When the vio-lets grow;
2. Sun-ny lit-tle blos-soms On their slen-der stalk,



s .s :s .s | l .d^1 :t .l | s :m | r :—

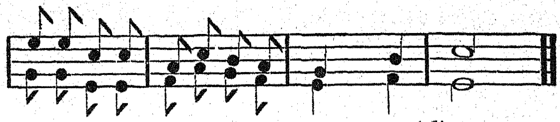
m.m :m.m | f .l :s .f | m :d | t_1 :—

When the birds sing sweet-ly, And the soft winds blow,
How much they would teach us If they could but talk;



s .s :t .t | r^1 :s | s .s :d^1 .d^1 | m^1 :—

t_1.t_1 :r .r | f :f | m.m :m .m | s :—

Comes the little dais-y, Bloom-ing fresh and fair,
Ev-er look-ing up-ward All the live-long day,

m^1.m^1:d^1.d^1 | l .d^1 :t .l | s :t | d^1 :— ||

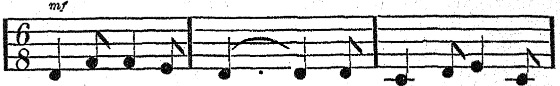
s .s :m.m | f .l :s .f | m :f | m :— ||

Spring-ing bright and joy-ous in the moun-tain air.
While their fa-ces bright-ly catch each sun-ny ray.

Exercise 67.—ROUND IN THREE PARTS—DOH ON SPACE BELOW LOWEST LINE.

Key D. JAS. SNEDDON, Mus. Bac.

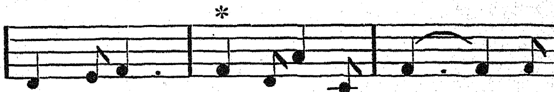
mf



d :- :m | m :- :r | d :— :— | — :— :d | t_1 :— :d | r :— :t_1

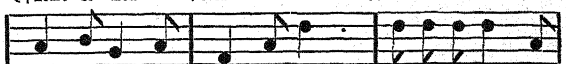
Up and down we go, Our boat so light, our

*



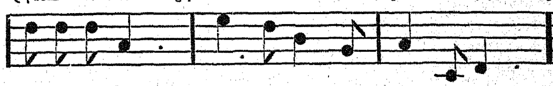
d :— :r | m :— :— | m :— :d | s :— :t_1 | m :— :— | — :— :m

heart so free. Cold the wind may blow, But



s :— :l | f :— :s | m :— :s | d^1 :— :— | d^1 :d^1 :d^1 | d^1 :— :s

still we're bound-ing o'er the sea. Spi-rits so gay, we're

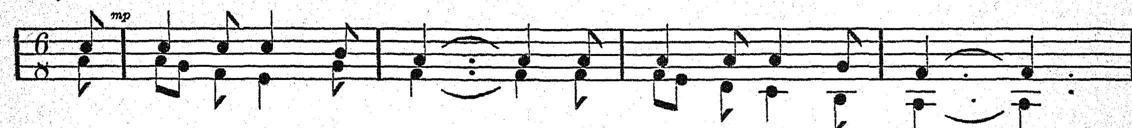


d^1 :d^1 :d^1 | s :— :— | r^1 :— :d^1 | l :— :f | s :— :t_1 | d :— :— ||

sail-ing a-way O'er the loud re-sound-ing sea.

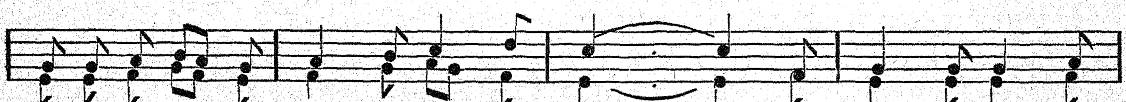
Exercise 68.—DOH ON FIRST SPACE.

THE MUSIC OF THE NIGHT.

Key F. REV. JOHN MALCOLM. JAS. SNEDDON, Mus. Bac.

s | s :— :s | s :— :f | m :— :— | — :— :m | m :— :m | m :— :r | d :— :— | — :— :—

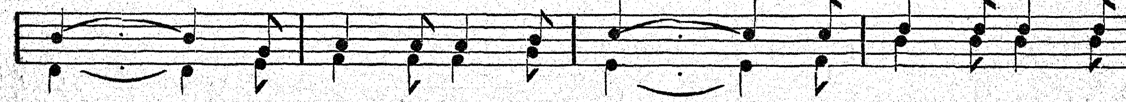
:m | m :r :d | t_1 :— :r | d :— :— | — :— :d | d :t_1 :l_1 | s_1 :— :f_1 | m_1 :— :— | — :— :—

1. The mu-sic of the night, Up-on its lone-ly flight
2. A-mid the still-ness round, As 'twere the shade of sound,
3. In them might fan-cy's ear Earth's dy-ing e-choes hear,



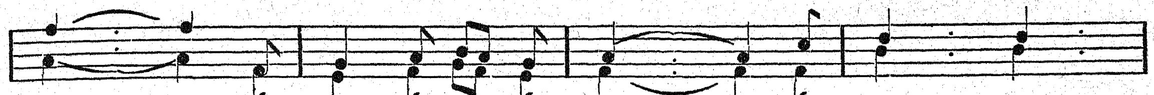
r :r :m | f :m :r | m :— :f | s :— :l | s :— :— | — :— :d | r :— :r | r :— :m

t_1 :t_1 :d | r :d :t_1 | d :— :r | m :r :d | t_1 :— :— | — :— :d | t_1 :— :t_1 | t_1 :— :d

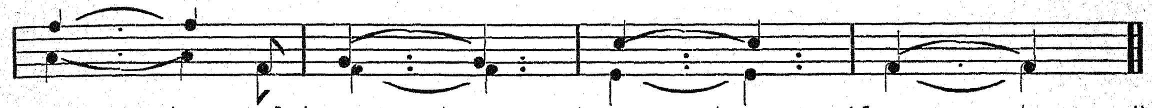
In-to the west, where sinks its ebb-ing sands; That muf-fled mu-sic
Floats on the low sweet strain of lull-ing tones; Such as from trem-bling
Our home's sweet voi-ces swoon-ing on the floods; Or song of fes-tal

f :— :— | — :— :r | m :— :m | m :— :f | s :— :— | — :— :s | l :— :l | l :— :l

l_1 :— :— | — :— :t_1 | d :— :d | d :— :r | t_1 :— :— | — :— :d | f :— :f | f :— :f

seems Like voi-ces heard in dreams, Sigh'd back from long-lost
wire Of sweet Æo-li-an lyre, With winds a-wake in
halls, Or sound of wat-er-falls, Or In-dian's dis-tant



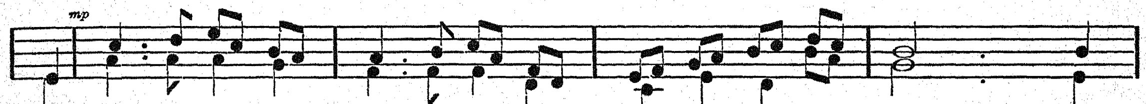
{|d' :— :— |— :— :d |r :— :m |f :m :r |m :— :— |— :— :s |l :— :— |l :— :— }
{|m :— :— |— :— :d |t, :— :d |r :d :t, |d :— :— |— :— :d |f :— :— |f :— :— }

years and dis - tant, dis - tant lands, From long - lost
mur - murs, mur - murs and in moans, A - wake in
war - whoop through the dis - mal woods, Or In - dian's

{|d' :— :— |— :— :d |r :— :— |— :— :— |s :— :— |— :— :— |d :— :— |— :— ||
{|m :— :— |— :— :d |d :— :— |— :— :— |t, :— :— |— :— :— |d :— :— |— :— ||

years and dis - tant lands.
mur - murs and in moans.
war - whoop through the woods.

Exercise 69.—DOH ON SECOND SPACE.

Key A. MARIA DOROTHEA OGILVY. THE GLOAMIN' HOUR. JAS. SNEDDON, Mus. Bac.

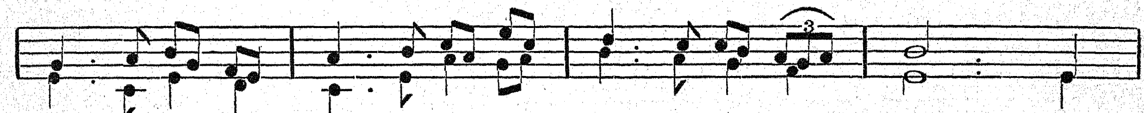


{:s, |m :- .f |s .m:r .d |d :- .r |m .d :l, .f, |s, .l, :t, .d |r .m :f .m |r :— |— :r }
{:s, |d :- .d |d :t, |l, :- .l, |l, :f, |m, :s, |f, :r .d |t, :— |— :s, }

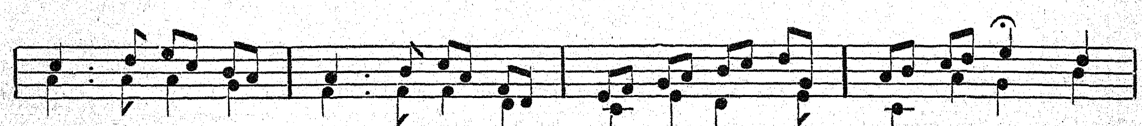
1. Oh! saft - ly fa's the gloam - in' hour, When fades the sum - mer day; When
2. There my - riad stars, as dia - monds bright, Sur - round the lad - y moon; She
3. The lin - tie's note to me is dear, The black - bird's eve - ning ca'; But

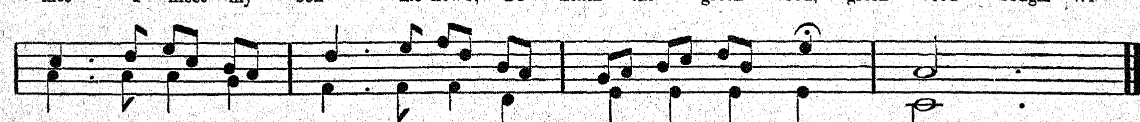
{|m :- .f |s .m:r .d |d :- .r |m .d :l, .f, |s, .l, :t, .d |r .m :f .t, |d :— |— :d }
{|d :- .d |d :t, |l, :- .l, |l, :f, |m, :s, |f, :- .s, |m, :— |— :m, }

sinks to sleep each ten - der flow'r Be - neath its less - 'ning ray. Now
waits to greet ap - proach - ing night; For me he comes too soon. The
Ma - ry's voice a - lone can cheer My heart at gloam - in' fa'. Oh



{|t, :- .d |r .t, :l, .s, |d :- .r |m .d :s .m |f :- .m |m .r :d .t, .d |r :— |— :s, }
{|s, :- .m, |s, :f, |m, :- .s, |d :t, .d |r :- .d |t, :l, |s, :— |— :s, }

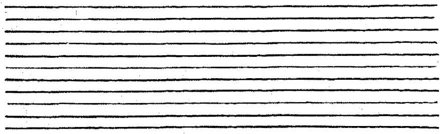
hush'd the air, the winds are mute, The bees have sipp'd their fill; I
heath - er clus - ters round my feet, The brack - en's wav - ing plume, Wi'
gloam - in' hour! Sweet gloam - in' hour, Dear to my heart art thou; Wi'

{|m :- .f |s .m:r .d |d :- .r |m .d :l, .f, |s, .l, :t, .d |r .m :f .t, |d .r :m .f |s :f }
{|d :- .d |d :t, |l, :- .l, |l, :f, |m, :s, |f, :- .s, |m, :d |t, :r }

hear the sounds of harp and flute In ev' - ry tink - ling, tink - ling rill. I
mony a flow'r that springs fu' sweet A - mang the gowd - en, gowd - en broom. Wi'
thee I meet my bon - nie flow'r, Be - neath the green - wood, green - wood bough. Wi'

{|m :- .f |s .m:r .d |f :- .s |l .f :r .d |t, .d :r .m |f .r :s |d :— |— ||
{|d :- .d |d :t, |l, :- .l, |l, :f, |s, :s, |s, :s, |m, :— |— ||

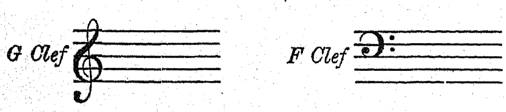
hear the sound of harp and flute In ev' - ry tink - ling rill.
mony a flow'r that springs fu' sweet A - mang the gowd - en broom.
thee I meet my bon - nie flow'r, Be - neath the green - wood bough.

Hitherto the position of Doh, the key-tone, has been given at the beginning of each exercise. The student should now be able to comprehend the manner in which this is usually and readily understood. The vocal organs of the human race may be broadly divided into four classes—viz. *soprani*, the higher voices of women and children; *contralti* (often simply *alti*), the lower; *tenori*, the highest of the male voices; and *bassi*, the lowest. In providing music for these we produce what is called four-part harmony. The female and unbroken male voice is naturally pitched an octave higher than that of grown men. The wide range required by these voices could not be shown on so limited a staff as that which up to this time we have been using. Although five lines and four spaces are generally all that are to be seen in a single group, the complete staff consists of eleven lines and ten spaces, and this is called

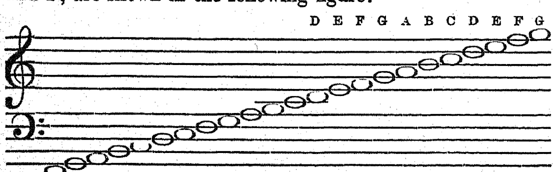
THE GREAT STAFF.



A *staff* of so many lines is not, as a rule, required for any single voice or instrument; even where it is required it would be cumbrous and perplexing to the eye if presented to it as a whole. From the great staff, therefore, a selection of five lines with their spaces is made for each separate voice and most instruments; and at the commencement of each piece characters called *clefs* are placed to show (1) from what part of the great staff the selection is made, and (2) for what voice or instrument the music is intended. Here we should explain that all the lines and spaces of the great staff are named from the first seven letters of the alphabet, and these for the different octaves are repeated over and over again just as the notes of the scale are repeated. The two clefs most frequently used are those known as the *treble* or G clef, and the *bass* or F clef.



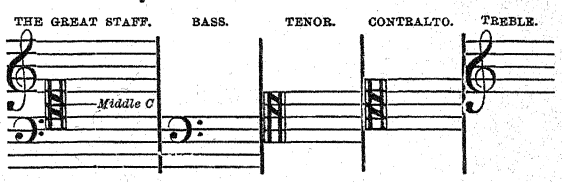
The position of these clefs on the great staff, the relation they hold to each other, and how they come to be named G and F, are shown in the following figure:—



The student ought to observe carefully (1) that the great staff is here, as is usual, broken up into two groups, the middle line, called from its position "middle C," being either left out altogether or employed, as in the figure, in the form of a ledger line above the staff for the bass, or below that for the treble. For convenience in writing, the distance or space between the treble and bass staves is often much greater than a single line would warrant, but however great the seeming separation may be, the *real* distance is as given, viz. two spaces and one line—B, C, and D. (2) The turn in the sign of the treble clef falls on the fourth line from the top of the great staff, and this clef receives its designation the "G clef" from the name of the line on which that turn is made. On the other hand, the letter (generally reversed thus) falls on the fourth line from the bottom, which line and clef are named F. The dots placed on either side of the line call attention to the same fact.

For pianoforte music the treble and bass clefs are both used in the manner just explained and exhibited, the piano being an instrument that requires the complete staff. Very frequently also harmony for four voices is presented in the same manner, two parts appearing on each staff, the notes for the higher voices having their stems turned up, those for the lower in the opposite direction. This is called "short score."

If a separate staff for each voice is required, the soprano or treble and the bass voices have the entire use of those just explained. The contralto and tenor voices having their best and most used notes about the centre of the great staff, middle C is taken as a new clef-note, and this sign placed thereupon is called the C clef. Its relation to the others may be shown tabularly thus:—



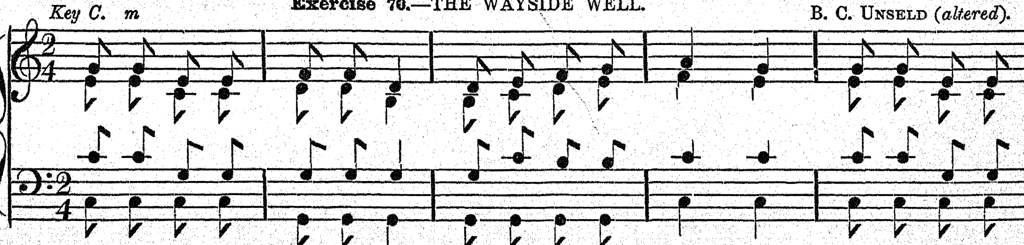
Here the lines are to be considered as if they had been drawn right along. The bass, as already explained, uses the five lower lines with t[illegible]s; the tenor voice, being higher set, does not requi[illegible] lower lines of the bass, and takes instead middle [illegible]e lower line of the treble, to make up its staff of [illegible]he alto, being a still higher voice, leaves off the [illegible] the bass and takes an additional line, G, from t[illegible] make its staff complete; the treble, as the studer[illegible]ows, takes the upper five lines; and thus every vo[illegible] its special staff.

It may be [illegible]tioned that in former days other clefs were used. T[illegible] contralto and tenor parts often appear on the treb[illegible], and in this case the tenor is written an octave high[illegible]an that in which it is really sung.

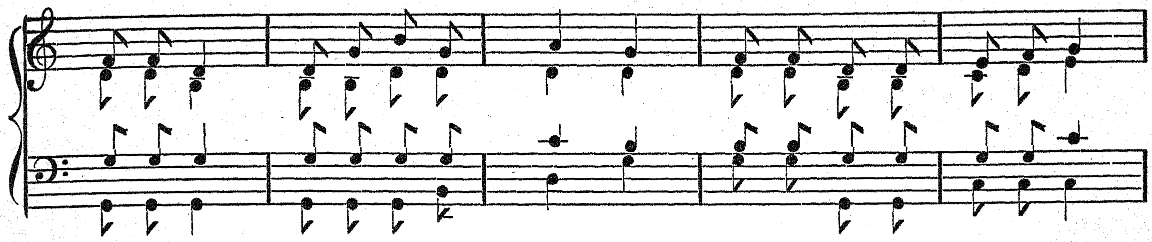
W[illegible] finish this section with simple examples in short score, in which the key-tone is to be considered as on middle C. The clef, and marks for time and key, placed at the beginning of every piece of music, is termed the *signature*.

Exercise 76.—THE WAYSIDE WELL.

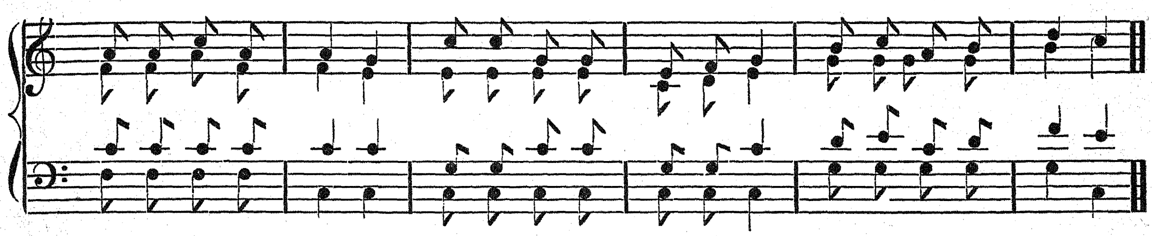
B. C. UNSELD (*altered*).



s .s :m .m	f .f :r	r .m :f .s	l :s	s .s :m .m
m .m :d .d	r .r :t_1	t_1 .d :r .m	f :m	m .m :d .d
d^1 .d^1 :s .s	s .s :s	s .d^1 :t .t	d^1 :d^1	d^1 .d^1 :s .s
d .d :d .d	s_1 .s_1 :s_1	s_1 .s_1 :s_1 .s_1	d :d	d .d :d .d
1. Oh the pret - ty	way-side well,	Wreath'd a - bout with	ro - ses,	Where, be - guil'd with
2. Treads the shep - herd	on the sward,	Comes the lab' - rer	to thee,	Free as gen - tle -
3. Fair the greet - ing	face as - cends,	Like a na - iad	daugh - ter,	When the peas - ant

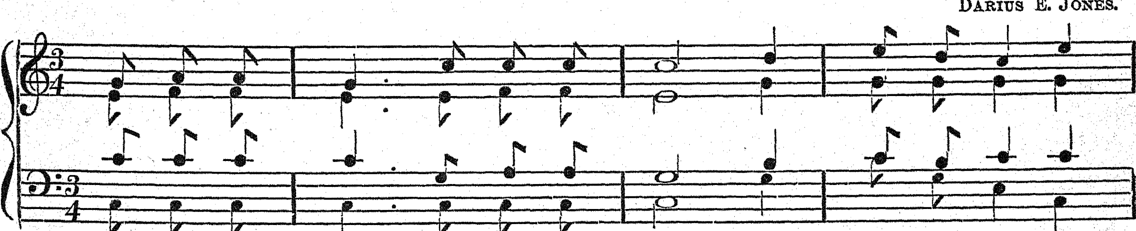


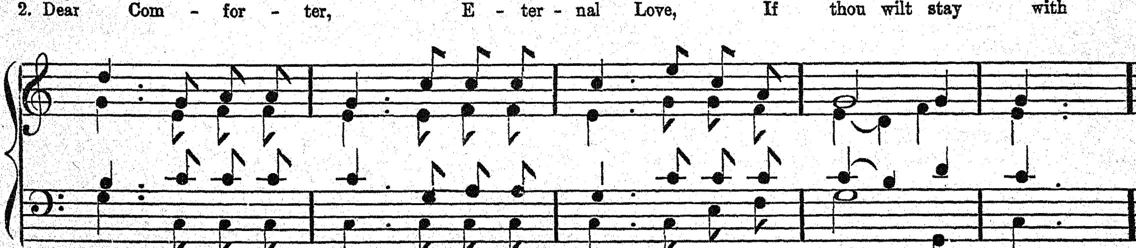
|f .f :r |r .s :t .s |l :s |f .f :r .r |m .f :s
|r .r :t_1 |t_1 .t_1 :r .r |r :r |r .r :t_1 .t_1 |d .r :m
|s .s :s |s .s :s .s |d^1 :t |t_1 .t :s .s |s .s :d^1
|s_1 .s_1 :s_1 |s_1 .s_1 :s_1 .t_1 |r :s |s .s :s_1 .s_1 |d .d :d

sooth - ing spell, Wear-y foot re - pos - es, With a wel - come fresh and green
man or lord, From his steed, to woo thee. Thou from parch - ing lip dost earn
las - sie bends To the trem - bling wa - ter. When she leans up - on her pail,

l .l :d^1 .l	l :s	d^1 .d^1 :s .s	m .f :s	t .d^1 :l .t	r^1 :d^1	
f .f :l .f	f :m	m .m :m .m	d .r :m	s .s :s .s	t :d^1	
d^1 .d^1 :d^1 .d^1	d^1 :d^1	s .s :d^1 .d^1	s .s :d	r^1 .m :d^1 .r^1	f^1 :m^1	
f .f :f .f	d :d	d .d :d .d	d .d :d	s .s :s .s	s :d	

Wave thy bor - der grass - es, By the dus - ty trav'ler seen, Sing - ing as he pass - es.
Many a mur - mur'd bless - ing, And en - joy - est in thy turn In - no - cent ca - ress - ing.
Glanc - ing o'er the mea - dow, Sweet shall fall the whispered tale, Soft the doubled sha - dow.

Exercise 71.—"ROBBINS," LONG METRE TUNE.

DARIUS E. JONES.

|.s :l .l |s :- .d^1 :d^1 .d^1 |d^1 :- :r^1 |m^1 .r^1 :d^1 :m^1
|.m :f .f |m :- .m :f .f |m :- :s |s .s :s :s
|.d^1 :d^1 .d^1 |d^1 :- .s :l .l |s :- :t |d^1 .t :d^1 :d^1
|.d :d .d |d :- .d :d .d |d :- :s |d^1 .s :m :d

1. Thy home is with the hum - ble, Lord, The simplest and the
2. Dear Com - for - ter, E - ter - nal Love, If thou wilt stay with

r^1 :- .s :l .l	s :- .d^1 :d^1 .d^1	d^1 :- .m^1 :d^1 .l	s :— :s	s :- .	
s :- .m :f .f	m :- .m :f .f	m :- .s :s .f	m :r :f	m :- .	
t :- .d^1 :d^1 .d^1	d^1 :- .s :l .l	s :- .d^1 :d^1 .d^1	d^1 :t :r^1	d^1 :- .	
s :- .d :d .d	d :- .d :d .d	d :- .d :m .f	s :— :s_1	d :- .	

best, Thy lodg - ing is in child-like hearts, Thou mak-est there thy rest.
me, Of love - ly thoughts and sim - ple ways I'll build a house for thee.

DRAWING.—CHAPTER III.

LIGHT AND SHADE.

OBJECTS become visible to us by means of light; their forms are made manifest to our senses by light and shade. Without light objects are invisible; without shadow they would appear flat and formless. In those branches of art-work which depend upon the realization of form, therefore, it is absolutely necessary to make a careful study of light and shade.

It is not absolutely necessary for an art-student to have a full scientific knowledge of the nature of light, or be conversant with the various theories respecting its motion; but it is desirable that he should both know and realize the results of the following facts:—That light, being propagated from a given source, such as the sun or a gas jet, travels with almost infinite velocity in straight lines or in a direct course. When objects are exposed to this flood of light they reflect or throw back a portion of it, and it is by this reflected light that they become visible to our eyes, as has been described in the preceding chapter, page 373. Some objects reflect all, or nearly all, the light which falls upon them, and these we call bright or light objects. Some absorb much of the light which they receive, and reflect little; these we call dark objects —that is, the general or natural tone of them is light or dark, even when they receive the same quantity of light. This can be very easily illustrated by pinning a piece of white paper on a black-board; the paper is white because it reflects the light largely, the board is black because it absorbs the light. These tones are called the local or natural tones, and are due to the substance or nature of the object. If we now take another object which is not flat, and which is of the same colour or tone all over, we shall find that when exposed to the light some portions will receive more light than others, while some will have no direct light falling upon them.

Suppose the object to be an egg, the source of light a candle or gas jet, and that the egg is placed on a piece of gray paper. It will be seen that the light falls fully on one spot, partially on other portions, while some parts receive none; a portion of the paper will be wholly deprived of light by reason of the egg standing between it and the candle. That portion of the object which receives the light fully is called "light," the portion which receives light partially is "half tone," the part which receives no light is "in shade," and the space on the paper which is wholly deprived of light is the "shadow."

We have, then, four different tones or gradations or "values" caused by the direct influence of light upon a rounded object. These tones the student should carefully look for, observe, study, and compare. These are the elements of light and shade; and if it were possible so to place an object that it could be illuminated by *one* light only, we should have only these elements to study and their effects to imitate. But in art-work we have other influences, and far more complicated results, to deal with.

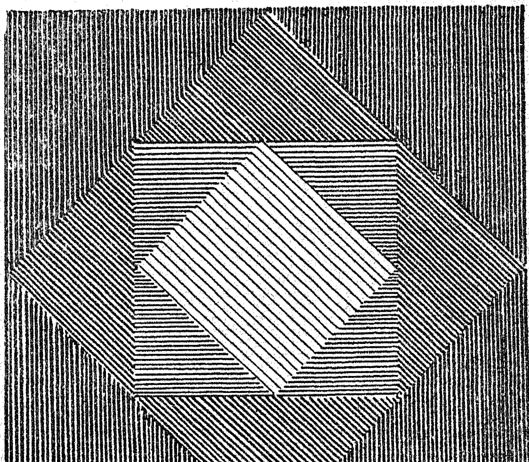
The gray paper on which the egg has been placed not only receives but reflects light. A portion of this reflected light is thrown back on to the *shade* side of the egg, and it becomes partially illuminated. The faint light which it thus receives is properly called a reflection, and if we consider that not only the paper, but all the other objects round about the egg, are reflecting light in various directions, and with varied intensity, we shall see that our first simple tones will be greatly altered and complicated. The result is, that wonderfully subtle gradations and variations of light and shade are to be found on the surfaces of even the most simple objects.

Before entering further with particularity into the *minutiæ* of this interesting subject—light and shade—it may be well to give the student a few instructions in the art of *shading*. He should first learn the wide difference between these two things. *Shading* is merely the art of imitating shades by means of the pencil, the brush, or some other instrument. Unfortunately, many students mistake the means for the end, and think that when they can imitate a shaded drawing or "shade from the flat" their education in that direction is completed. This idea has been encouraged, in past times, even in so-called schools of art, and students have been allowed to waste valuable months in the painful and useless elaboration of drawings copied from tasteless lithographs. Absolutely nothing is to be learned by such work except the ability to make an imitation of a shadow or shade by means of some instrument, and this ability any industrious student should be able to acquire in a few weeks by working out the exercises given in this chapter.

We shall in these instructions suppose the student to use the pencil or the brush. It is not necessary to describe minutely the methods of working with other instruments, as they are almost exactly the same. The pencil, the crayon, the "stump," and the pen are used in a very similar manner. The first thing to acquire is the ability to lay on a flat shade; that is, to cover a certain space with an even tone. The best kind of paper will be a moderately coarse-grained water-colour drawing paper, called at the art-stationery shops "Whatman's medium." This will require to be well strained on a board. The straining is done as follows:—A piece of paper rather less in size than the drawing board used should be slightly damped by dabbing (not rubbing) a wet sponge upon it. The paper should be laid with the damp side up, evenly, on the board. About one inch of the edge all round should then be turned up and folded inwards. This edge should next be carefully glued or gummed, the solution of gum used being strong all along. It should thereafter be folded back again on to the board. No importance should be attached—in fact no notice need be taken—of the fact that it cockles or wrinkles up, and does not lie flat and stick along the edge. As it is desirable to preserve the perfect purity of the paper it will be wise to lay another sheet of clean waste paper on the top of the drawing paper; then, on the top of that, another board or a flat card should be laid; and, on the top of all, one or two heavy books should be put. The whole having been left undisturbed for some hours, the damped paper will then be found to be dry, the edges firmly fastened to the board, and the surface as firm and hard as the board itself. As there is a sort of art in this too, it is just possible that a perfectly successful result may not follow the first effort; but it is a useful thing to know how to strain paper properly, and the student in this, as well as in many other matters of detail, will do well to lay to heart the doctrine of "try again."

When the paper has been thus successfully prepared, a combination of squares should be drawn upon it, as shown at Fig. 1, and an endeavour should be made to cover these

Fig. 1.

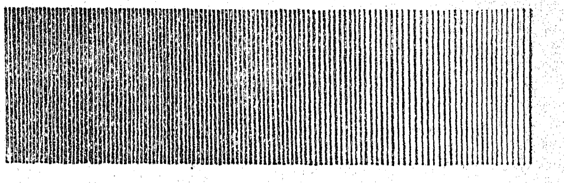


squares with graduated flat tints, as shown in the same figure. If the pen, the pencil, the crayon, or the stump be used, the tints should be commenced with a series of parallel lines, very strong on the darkest parts, and very light and tender on the lightest. To make a dark tint it will be found necessary to go over the space again with a second series of

lines crossing the first at an acute angle. It may even be requisite to cross these with a third series of lines, and then the small openings which will be left should be filled in with small touches done with a fine point; this is called *stippling*, and may be carried as far as is felt to be desirable. When the tint is flat and even all over, that is all that need be aimed at. It is not really any the better for being made fine by laborious stippling. The lines used for constructing the squares should be very light. They should disappear altogether when the figure is shaded, and the spaces should be distinguished from each other only by the difference in their tone.

The same exercise may be worked with the brush, a wash of very light colour being put *all over* the figure, darker tones being put on the various spaces, as seen at fig. 1. The method of "washing" on these tones has already been described in Chapter I., p. 278. These exercises should be patiently repeated several times, as it is almost inevitable that the paper should get into a hopeless condition during the course of the earliest series of attempts. The student may next take a small prism, hexagonal or octagonal in shape (directions for making such objects have been given in last chapter, p. 372), and placing it in a side light, an endeavour should be made to imitate the varied tones seen on its faces. This object might be placed in various positions, and copied several times, until the difference between the flat shades on its faces becomes evident, and can be fairly well expressed. A graduated tone might next be tried, such as that shown at fig. 2, but not necessarily obtained by means of the parallel lines there used. This is in reality one of the

Fig. 2.



most difficult exercises; and when sufficient ability has been acquired by the student to make a good graduated tone, on a fairly large space, he will know enough about "shading," and may therefore go on with the further study of light and shade.

Let the hexagonal prism mentioned above be now placed

Fig. 3.

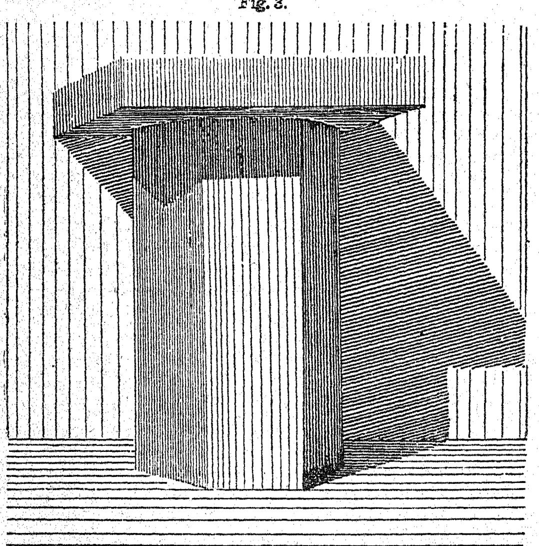
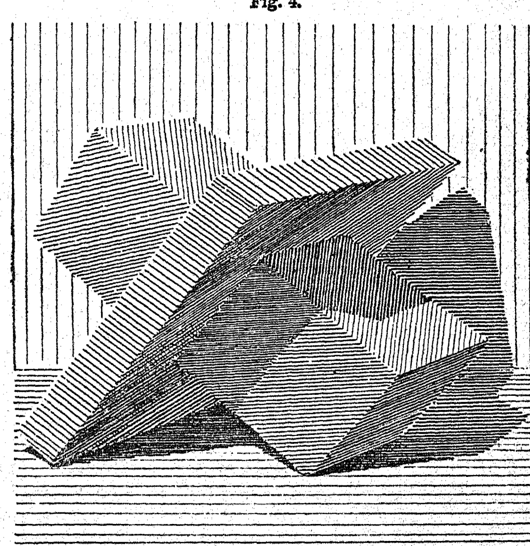


Fig. 4.



in a good side light, with a card behind it and a book or flat slab on the top (fig. 3). With these objects in such a position we shall have some parts light, a few simple and well-defined shades, a reflection from the card, and shadows cast by the block on to the prism, and by the prism on to the card. The figure here given is not intended to be copied. The objects themselves should be placed in a similar position, and the details of light and shade under varied lights ought to be carefully studied. The shadows cast by the block upon the prism and by the prism on the card will be found to be the darkest tones The forms of these shadows should be carefully drawn in outline; indeed the shadows, and even some of the shades, should always be drawn in outline before the actual shading is commenced. The form of the object—or rather, the appearance which it assumes to the eye—is due to the shape and intensity of the shadows and shades upon it, as well as to the actual boundaries or edges of the object itself. In drawing these shadows it will be discovered that the shape of shadows is influenced by three things—(1) the form of the object casting the shadow; (2) the position of the plane or surface on which the shadow falls; and (3) the position of the light. When these three things are well defined the resulting shape of the shadows can be demonstrated with scientific accuracy. The shadows in fig. 4, for example, have been worked out according to the strict laws of perspective. These laws are, of course, applicable to more elaborate and irregular objects, and it will therefore be evident that the forms of shadows, being subject to known and well-defined laws, should be accurately drawn.

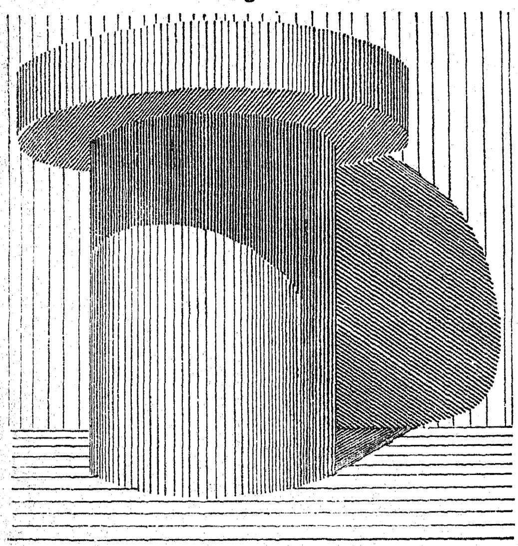
When the shadows on the above-mentioned objects have been drawn, the spaces which they occupy should be filled in with a fairly strong, though not black, tone. The *relative strength* of all the other tones should then be most carefully studied; they will all be lighter than the cast shadows, and the lightest will probably be as light as the paper on which the work is done, and therefore may be left untouched.

A cylinder may next be put in the place of the prism, a circular slab resting on the top. We shall now have rounded surfaces to deal with, and these are much more difficult to imitate than the flat planes of the prism and the square slab. In this case, again, the shape of the shadows should be most carefully indicated by a light outline, and filled in with a strong flat tone; the size or width of the darkest part of the shade on the rounded surfaces of the slab and the cylinder should be drawn and shaded in a similar manner, and these darkest parts *gradated* into the light. This gradation will require the student's utmost skill and patience. In this study the reflections or reflected lights will be obvious (see fig. 5). These reflections are frequently omitted, or not seen, by students in the earlier stages of their education; and afterwards, when these lights have been pointed out or become evident, they are frequently exaggerated. It should be borne in mind that though the reflected light is apparently strong when compared with the dark shade in which it occurs, it is in fact a *shade*, and many degrees

darker than that portion of the object on which the direct light actually falls.

As an exercise in object drawing in proper light and shade a group of objects similar to that shown in the Plate, or an egg placed upon a piece of gray paper (as previously described) might now be attempted; and if a successful drawing can be made of this, a great step in advance will have been made. The student is strongly urged to work

Fig. 5.



patiently and assiduously at these elementary exercises, endeavouring to get the roundness and solidity which are perceived in the simplest forms distinctly and accurately expressed. In most single objects only one spot (the high light) will be perfectly white, and tones more or less deep will be found on all other parts. Flimsiness and indefinite indications of shadow-forms should be avoided. It is impossible to study too closely the shapes of the shadow-edges, and the relative strength of their tones. These tones and forms will be best seen when the eyes are half closed, and the effect of the numerous reflected lights is thereby lost. The student should frequently so look at the object, and endeavour to get the broad effect which will be seen in that way. Even when more elaborate objects than those which have been mentioned are taken in hand, it would be advisable to keep to objects of one tone or colour (monochrome), for great as are the difficulties to be encountered when imitating the forms of such objects, these difficulties are increased tenfold when an attempt is made to copy the light and shade of a coloured object. Let the student try to copy the form of an apple, taking no notice of its colour, but imitating only its form in black and white. In such an exercise it will be necessary to forget that the apple has colour at all, and to look only for the roundness. The want of early training in light and shade is frequently shown by students who attempt to paint a piece of fruit from nature; the colour is so obvious and so attractive, and demands so much attention, that the light and shade is almost entirely neglected or forgotten, and the form is expressed (or supposed to be expressed) by what is in reality merely a flat patch of colour more or less like that of the object.

In this lesson nothing will be said about the imitation of colour and light and shade; for the present we desire to point out that the two things are for the most part separate and distinct, although in nature inextricably mingled and combined. Beautiful drawings, expressing every detail of subtle form, can be made without colour, and some writers think that this is all that should be attempted by those who have only their leisure time to give to the study of drawing. Colour is a great study, not to be lightly attempted, yet so attractive as not to be altogether omitted without a feeling of painful regret. None of us would like to live in a colourless world; and after the student has begun to see the beauties of light and shade, and how much depends upon the imitation of these, then, but not till then, may he begin earnestly to search out the mysterious loveliness, instinct with inexpressible beauty and grace, of light, shade, and colour combined in ever-varying attractiveness and charm.

TRIGONOMETRY.—CHAPTER V.

ANGULAR MEASUREMENT—SOLUTION OF ANGLES—PRACTICAL USE OF LOGARITHMIC CALCULATION.

One of the most important practical points in the trigonometrical solution of rectangular (or indeed of any other sort of) triangles is to get some one of the sides of the triangle to be resolved, so placed as to be able to be taken as the radius of a circle, at the centre of which this radius forms, with one of the other sides, an acute angle. On page 377 we have shown, geometrically, how this may be done; and the trigonometrical deductions which may be made from them are exhibited on page 378. We now desire to show how the practical work of resolution is accomplished, and the simplicity of the means by which singularly difficult measurements are managed by trigonometry.

Having arranged the line which shall be regarded as the radius—and upon the thoughtful skill with which this is done, the ease, facility, and accuracy of the work depend a great deal—we can readily trace out and determine the relations which the other lines bear to one another and to the circle in which that radius has place, or any other circle with which we may find it desirable to bring them into relation. We already know that the following rectangles are each of them equal to the square of the radius—viz. (1) the sine and cosecant; (2) the cosine and secant; and (3) the tangent and cotangent. We also know that the same angles may belong to an infinite number of (possible) triangles, all of which must have their corresponding sides similarly proportional one to another (see page 280), because "two triangles which have an angle of the one equal to an angle of the other, are to each other as the rectangles of the sides which contain the equal angles." Now, as equal arcs or angles have equal trigonometrical lines, when we have or can form equal arcs or equal angles, we are sure that these lines are equal, and when we have or can form proportional arcs or angles, we know that these lines will be correspondingly proportional. As, too, when either arcs or angles are equal, their supplements or complements are equal, the trigonometrical lines belonging to these supplements or complements must also be equal, and their proportions hold good, one with another, in all cases and consequences to which their similarities extend.

In geometrical trigonometry all angles are calculated as lying between the limits of zero [0] and two right angles [180°]. Every angle, unless it be at the extreme limits of 0 and 180°, must be either (1) right, (2) acute, or (3) obtuse. A right angle is one of 90°. Two angles which together make up two right angles [180°], are *sup*plementary angles, and each is called the supplement of the other. Two angles which together make up one right angle, are called *com*plementary angles, and each is called the complementary of the other. Hence the two acute angles of any right-angled triangle are complementary; and the complements of angles of 70°, 60°, 50°, 40°, 30°, and 20°, would be respectively 20°, 30°, 40°, 50°, 60°, and 70°; similarly the supplementary angles of 170°, 160°, 150°, 140°, &c., would be respectively 10°, 20°, 30°, 40°, &c., and *vice versa*. As the numerical value of the sine (and all the other trigonometrical ratios) of an angle depends on the magnitude of the angle, and the magnitude of the angle is usually indicated or measured by the number of degrees, minutes, &c., it contains, it is useful to know how, when in a right-angled triangle one of the two acute angles is given, to find the other. In Euclid I. 32, it is demonstrated that "the three interior angles of every triangle are equal to two right angles." In every right-angled triangle, one being 90°, the others can only have the other 90° divided between them. We have only, therefore, to subtract the given angle from 90° and we have the other. The *formulæ* for these processes are very simple—viz. in any right-angled triangle A B C, of which the angle at B is a

DRAWING.

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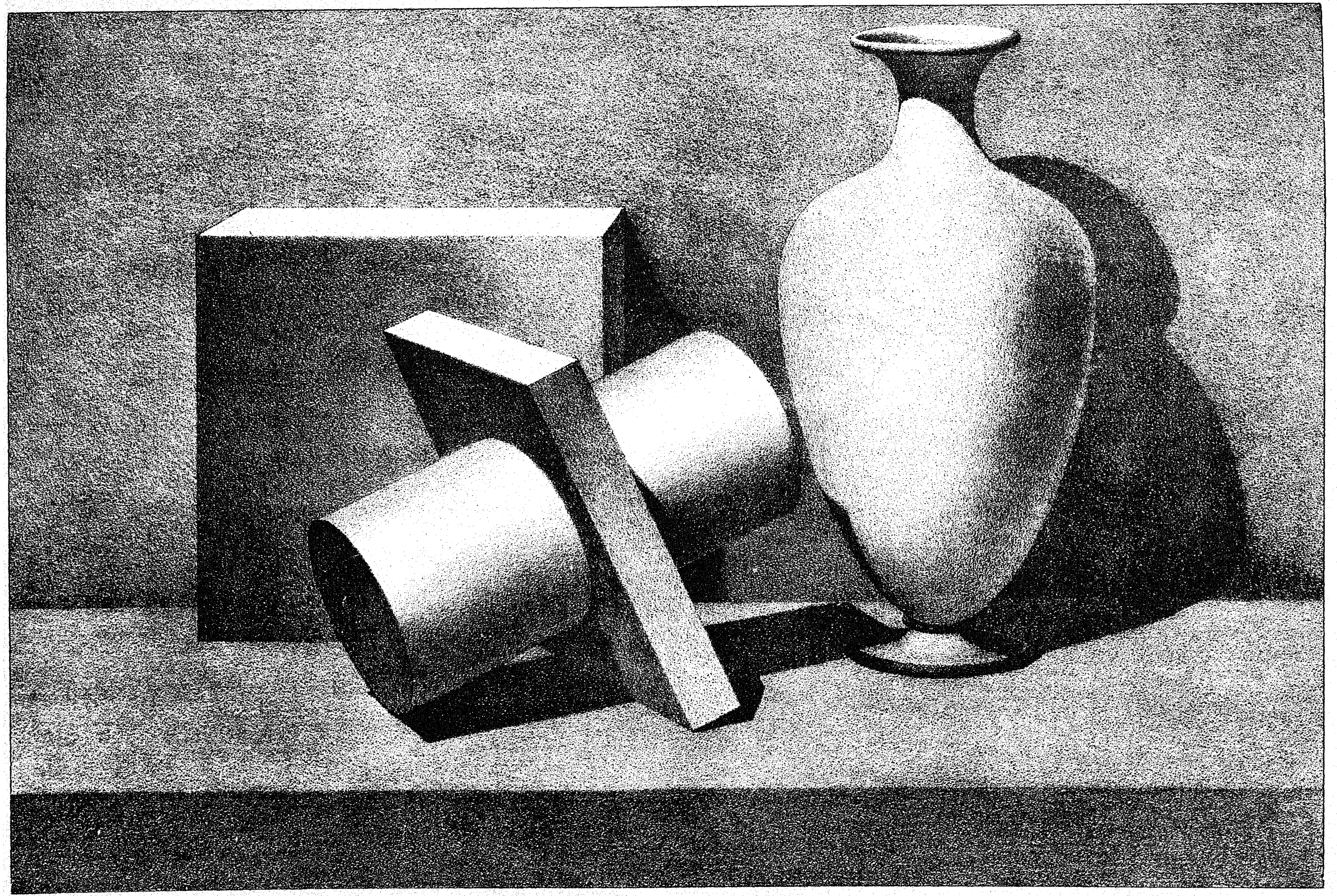


right angle, (1) angle A equals 90° − angle B, and (2) angle B equals 90° − angle A. Thus, if one of the acute angles of a right-angled triangle is 35°, the other will be 55°. Similarly, one of the acute angles of a right-angled triangle is $39\frac{1}{2}$°, what is the other? Ans. $50\frac{1}{2}$°. What is the acute angle at the vertex, if that at the base is 71° 46′? Ans. 18° 14′. What is the acute angle at the base when that at the vertex is 64° 28′ 37″? Ans. 25° 31′ 23″. In like manner we are able to find the angles of any right-angled triangle when we have either of the acute ones given.

It is somewhat different, however, in the case of oblique-angled triangles. In these we require to have two angles given in order that we may be able to determine the amount of the obliquity of the departure of the third. The three interior angles of every triangle are together equal to two right angles; and hence, if we subtract the sum of any two given angles from 180° the third angle will be found. The *formulæ* in this case are three, viz.:—(1) Angle A equals 180° − (angle B + angle C); (2) angle B equals 180° − (angle A + angle C); and (3) angle C equals 180° − (angle A + angle B). For instance, let angle A = 31° 13″ and angle B = 48° 24′ 15″, then angle C = [180° − (31° 13′ + 48° 24′ 15″), *i.e.* 79° 37′ 15″] = 100° 22′ 45″. Similarly, if B = 39° 15′ and C = 13°, A will equal 127° 45′.

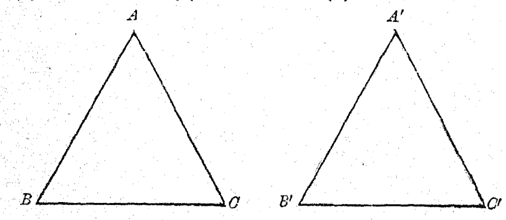
Two angles of a triangle are A 72° 16′ and C 38° 40′; of how many degrees is B? Answer, 69° 4′.

The angles at the base of an isosceles triangle are 43° 47′ 51″. What is the vertical angle? Answer, 92° 24′ 18″.

Angle A is 49° 25′ and angle C is 63° 48′, and therefore B is? Answer, 180° − 113° 13′ = 66° 47′.

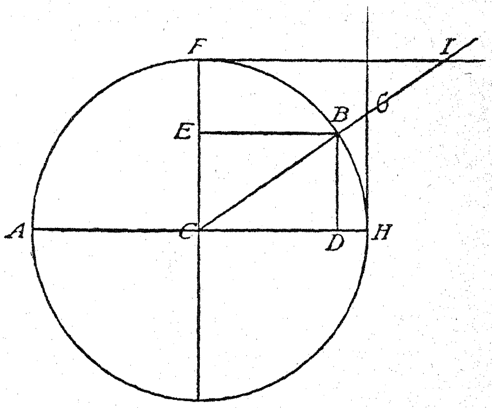
Bearing in mind, then, that in every case in which the equality to two triangles is asserted, the following six conditions must always be fulfilled, viz.—

(1) AB = A′B′. (2) AC = A′C′. (3) BC = B′C′.
(4) C = C′. (5) B = B′. (6) A = A′.



We can proceed to put the theory of the equality of triangles to further uses; for whenever we can make sure of the equality of two triangles in any three elements (of which one is a side), we can be quite sure of their equality in all the other three.

Considering then that, when from the vertex of any angle a circle is described with any radius, the intercepted arc is the measure of the angle, and that that arc is proportionally to a quadrant (or fourth part of a circle) what its angle is to a right angle, we know that equal arcs and equal angles have equal trigonometrical lines. In any circle the chord of 60° is equal to the radius—for, being the chord of the sixth part of the circumference, it is the side of a regular hexagon, which is always equal to the radius of its circumscribing circle. The sine of 90° and the tangent of 45° also each equal the radius. All trigonometrical lines of the same name belonging to different angles have the same relation to one another as their angles, their arcs, or their radii have to one another. Thus, referring to the diagram, the ratio of the arc HB to the radius CH, *i.e.* HB ÷ CH, is the measure of the angle H C B. In the same way, the *sine* of the angle H C B may be represented by B D ÷ C H, its *cosine* by C D ÷ C H, its *tangent* by HG ÷ CH, its *secant* by CG ÷ C H, its *cotangent* by F I ÷ C H, and its *cosecant* by C I ÷ C H. C H, the radius, is usually regarded as the unit, and the sines, cosines, tangents, &c., are expressed in terms of that unit in the trigonometrical tables. By such carefully-thought-out inductions, and certain happy contrivances, ultimately depending for their trustworthiness upon them, we are enabled to carry on computations concerning angular magnitude, leaving out of account angular measurement altogether, and taking those trigonometrical straight lines as so many linear quantities having certainly-fixed relations one to another and each to each. As the sine depends upon the arc, or upon the angle of which the arc is

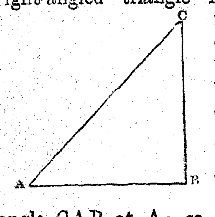


the measure, we require to know the angle in order that we may know the sine; but the sine being known, all the other relations are constant and calculable. On the basis of a knowledge of the sine, therefore, trigonometrical tables have been so constructed that either (1) their numbers express, in terms of the radius, the proportional length of the sines, cosines, tangents, secants, cotangents, cosecants, &c., of all the possible arcs in a circumference, and so furnish numbers corresponding to any given arc, whatever its extent in degrees, minutes, seconds [or decimals]—in which case they are called Tables of Natural Sines, &c.; or (2) their numbers express the logarithms of these natural sines, &c., and then they are Tables of Logarithmic Sines, &c. But, as we have previously shown, the cosine A = sin [90° − A], and hence a table of the values of the sines may, by ready computation, be made a table of the value of the cosines. Similarly, because the tangent A = sin A ÷ cos A, the logarithm* of the tangent of any angle may be obtained by subtracting the logarithm of the cosine from that of the sine; while the logarithm of the cotangent is obtainable by the subtraction of the logarithm of the sine from the logarithm of the cosine.

In this way—except in a few cases where the angles differ very slightly from 0° or from 90°, when some peculiar modes of operating require to be carefully observed—nearly the whole art and mystery of trigonometry consists in being able to manage and manipulate the sines and the computations necessary to transform them into their proportionals. There are 5400 (*i.e.* 90 × 60) minutes in a quadrant, and therefore so many arcs, at least, require to be calculated as shall supply the figurate values of the sines, &c., of these several arcs. The smaller quantities of seconds really require that only all the possible sines of one minute should be calculated. If we imagine the sine as a straight line, capable of continuous extension, movable constantly along the radius, so that as the arc increases in size, it is brought nearer and nearer to the quadrant or radius of 90°, so as at length to coincide with it, we shall readily be able to trace the simultaneous growth of the sine, as the arc grows. Its simultaneous and proportional decrease as the arc passes beyond the angle 90°, and throughout the second quadrant towards 180°, is equally easily understood. Exactly similar will be its increase and decrease in the two lower quadrants. Hence we perceive that *the sine of an arc is equal to the sine of its supplement.* Take, for instance, an angle of 131° 45′, its supplement is 48° 15′, and the sine of 131° 45′ = the sine of 48° 15′. This may be otherwise expressed thus: sin 180° − A = sin A, and sin 90° + A = sin 90° − A. It is equally plain that the tangent and

* Logarithms are a series of artificial numbers so arranged as to correspond to a set of natural numbers, in such a way that the sum of the logarithms of any two numbers is the logarithm of the product of these numbers; so that, by logarithms, multiplication is performed by addition, and division by subtraction.

secant of any angle are likewise the tangent and secant of the supplement of that angle. Following out the same course of observation, the careful student will readily see that *the sine, tangent, or secant of the complement of any angle is the cosine, cotangent, or cosecant of that angle;* and it will not require much further thought to deduce from these observed facts the easy inference that the radius of any angle is a mean proportional (1) between the tangent and cotangent, and (2) between the cosine and secant of that angle. We may now proceed to present this statement as a fact, viz. If in any right-angled triangle A B C, the hypotenuse be made radius, the perpendicular B C becomes the sine, and the base A B the cosine of the angle at A, while the base A B is the sine, and the side C B the cosine of the angle at C. If, on the other hand, the base A B be made the radius, the perpendicular B C becomes the tangent, and the hypotenuse the secant of the angle C A B at A; so that *the sides of any right-angled triangle are to one another as the sines of their opposite angles.* This, stated in other words, signifies (1) that if in any right-angled triangle the hypotenuse is regarded as the radius the sides become the *sines of the opposite angles;* (2) that, if one of the sides be made the radius, the other side becomes the tangent of the opposite angle, and the hypotenuse the secant of that same angle.



With these remarks thoroughly understood there should be no difficulty in perceiving how to deal with right-angled triangles at any rate. But we shall illustrate this in a given case with some painstaking. Let the case be one in which there is *given, in a right-angled triangle, one of the angles and the hypotenuse, to find* (1) *the base,* (2) *the perpendicular; e.g.* angle 53° 8′, hypotenuse 480 feet. This might be done either (1) by construction, (2) by calculation, or (3) by the use of Gunter's scale. The method by construction is not so accurate as the others, although it is advisable to be acquainted with the different methods, that the one may be used as a check upon the other. In the meantime we proceed by calculation. In a right-angled triangle having one angle 53° 8′ *given,* we have also the other implicitly so, *i.e.* angle C = 90° − 53° 8′ = 36° 52′. If now the hypotenuse is made radius, B C will be the sine of the angle A, and A B the cosine; and the form will be radius A C : sine B C : : 480 : A B. In the table of natural sines we have as the calculated ratio of 53° 8′ the figures ·8000338, which we multiply by 480, and the result is (as may easily be shown) as nearly as possible 384 feet, the length of B C.

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  ·8000338
       480
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 640027040
32001352
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384·0162240
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Again, we have the angle 36° 52′, and because the sine of either of the acute angles of a rectangular triangle is the cosine of the other, and *vice versa,* A B is the sine of C. Of this the table of sines supplies us with the figurate equivalent ·5999549, which, of course, we multiply by 480, and get as our result (taking the nearest complete whole number) 288 feet for the length of A B. The three sides are therefore A C 480, B C 384, and A B 288. Done by the logarithmic tables the calculations are made thus:—

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  ·5999549
       480
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 479963920
23998196
----------
287·9783520
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To find B C.

Radius [sine of 90°],	1000000
: Hypotenuse [480],	268124
: : Sine [53° 8′],	990311
	1258435

To find A B.

Radius [sine of 90°],	1000000
: Hypotenuse [480],	268124
: : Cosine [53° 8′]	977812
	1245936

Subtracting from each of these sums the logarithmic radius number, and looking in the columns of the tables of sines, we find opposite 258435 the number 384, and opposite that of 245936 the number 288. That this is the fact the learner will require to take for granted at present, until we have explained the logarithmic tables and their uses. Meanwhile he may proceed to examine and work out, in a similar fashion to the above, the following:—

In a rectangular triangle the angle A = 18° 14′, and the side A B 432 feet; find the sides B C and A C, and the angle B.

The angle B is evidently 71° 46′, of which the sine is ·9497902. The sine of angle A, 18° 14′, is given as ·3128875.

If these be each multiplied by 432, they will yield for B C 135·167, and for A C 410·31.

HISTORY OF GREAT BRITAIN AND IRELAND.

CHAPTER IV.

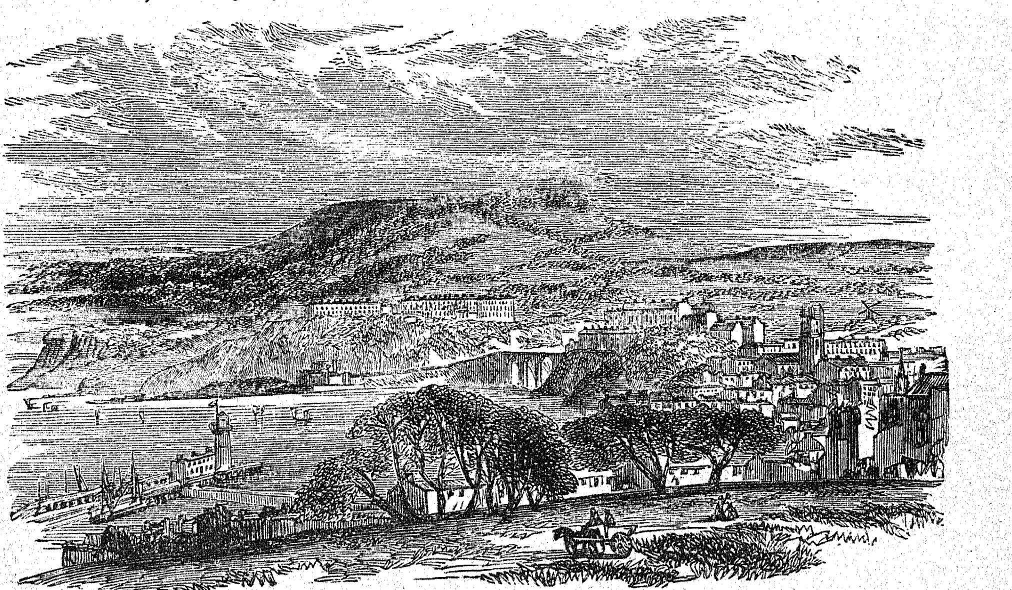
HAROLD THE SAXON—THE BATTLES OF STAMFORD BRIDGE AND HASTINGS—THE CONQUEST OF ENGLAND—WILLIAM THE CONQUEROR.

HAROLD, the last of the Saxon kings, was made in 1850 the subject of a romance by Lord Lytton, and in 1876 Lord Tennyson adopted the same theme for one of his dramatic efforts. A real dramatic romance was Harold's life indeed, and one well worthy of the lordly pens which were employed to realize for us the incidents of the reign closed in the terrible storm of battle on "the day of St. Calixtus," pope and martyr. Crowned by the choice of the people, in accordance with the will of Edward, on Twelfth Day (6th Jan., 1066), Harold, as the best man of English breed in the island, took his seat on the throne. Godwin's son undertook the sovereignty in a business-like way, and maintained the dignity of monarch quietly and well for a time. But William of Normandy—asserting that Edward had bequeathed the overlordship of England to him, and relying on a promise he had extorted from Harold, that he would do everything in his power to aid Duke William's succession to the sovereignty of Saxon England—decried him as a faithless usurper and claimed the crown.

When William, in his park near Rouen, was one day trying a new bow, certain Normans, whom Harold had expelled from England, came to state their grievances, and at once announced the demise of Edward and the coronation of Harold. William heard the news calmly, handed his bow to an attendant, took a boat across the Seine, and silently, yet thoughtfully all the while, passed on to his palace. There he gave way to agitation, and wrathfully strode up and down the great hall, while awe hushed the soul of each attendant. His resolve was promptly taken. "For Edward's death," said he, "there is no remedy; for Harold's treachery there is!" William assembled his councillors, and they agreed with him that ambassadors ought to be despatched immediately to England to assert his rights. They came to Harold. He repudiated the claim, and sneered at the claimant. "My royalty is the gift of my countrymen, and my right, so gained, I will not resign to any foreign power." They carried the message to Rouen, and William sent them back with a commission threatening invasion and war. Harold mildly replied, "Let him do his worst!" Meanwhile half of the idle adventurers of Europe heard with delight of the likelihood of sword-play and spoil. The Norman invasion of England was urged with jubilant glee by them. Anselm, formerly bishop of Lucca, was now pope, as Alexander II. To him William presented a claim of right, and he, arbitrating between the pretensions of Harold and William, decided in the duke's favour, gave him a holy license to invade England and to bear rule over it, when conquered, as a fief of the church. A pontifical diploma, a consecrated banner, and a ring containing one of the hairs of St. Peter, were sent to him as tokens of the approval of the Roman see. Hildebrand (afterwards Gregory VII.) was William's advocate at the papal court. In the early spring Harold's kingdom was taken possession of, on paper, by the church, and William was preparing to seize it by the sword. Harold exchanged the palace for the camp. He assembled the largest army and the most numerous fleet England had

ever seen or supplied. The former he took to Sandwich, on the Stour, in Kent, and the latter he ranged about 2 miles off in the Straits of Dover, to watch the south-east coast against the menaces of the enemy, whose headquarters were at Lillebonne. Harold's prompt daring won the nation's heart. But Tostig, the king's brother, who had been expelled from the earldom of Northumbria, opened communications with Duke William from the court of Flanders, and at last visited Lillebonne. There Tostig boasted of his power and popularity in England, and offered to aid the duke in the conquest of the country. William politicly took advantage of this traitorous offer, and gave him sixty ships to go as a pioneer in the war. With these Tostig ravaged the Isle of Wight. He was forced to retreat before his brother's armament, and made his way to the Humber. There he was met by Morcar of Northumbria and his brother Edwin, sons of Alfgar. They repulsed him and he fled, with twelve smacks, to the north of Scotland. Thence he went to Denmark, and urged Sweyn to bring out the forces of the Baltic for the conquest of England. The Danish king declined the adventure. Harold Hadrada ("brave in counsel"), the king of Norway, was next tempted, and the cry was raised, "Westward Ho! for England." The raven banner flapped over the Norwegian fleet of 240 fighting ships, besides transports and cutters, gathered together at the Solund Isles, whence was the shortest route to Shetland, to convey 20,000 men to conquer the islands of the west. On 1st September, after wearisome delays, Hadrada's fleet was ready. Off it set for Shetland and Orkney, gathering as it went, till his boats numbered nearly 1000 and his army 30,000. They steered south to Northumberland. Tostig, who had been the guest of Malcolm of Scotland, joined Hadrada off the Tyne, and there did homage to him as his liege lord. They landed in Cliffland (*Cleaveland*), Yorkshire, and subdued the sea-coast to the Humber's mouth. Up the Ouse towards York they sailed. Edwin and Morcar met them at Fulford. The Norwegian's banner, the *Landeyda* ("land-waster"), flew on the left wing beside the river. At first, the earls made a successful onslaught; but Hadrada turned the tide, and on that day, 20th September, thousands lay, for miles round, "weapon-smitten." On Sunday, 24th September, the Northumbrians agreed to meet the invaders beside Stamford Bridge to treat of terms of surrender, and to deliver their 500 hostages for their fidelity; and that day Hadrada and Tostig entered York as its masters, and left it believing their stars were in the ascendant.

Meanwhile Harold, who had been watching William at Sandwich, had been quite outwearied, and, his provisions failing, he had disbanded his land forces on 8th September, and ordered his fleet to betake itself to London. But the blaze that lighted up Scarborough threw its glare south, and the news of the invasion of the north by his namesake of Norway roused Harold to instant energy. Calling out the



Scarborough.

terrible Thingmannalid—a band of mercenary soldiers, who had originally come from Jomsberg, on the east coast of the Baltic, and entered the service of the English sovereign on condition of being well fed, clad, and paid—summoning the house-earls or king's private body-guard, and raising the yeomanry of the midlands on his way, Harold marched night and day, with "seven bands" of Englishmen, to meet and do battle with the foe. On Sunday morning he reached Tadcaster, 9 miles south-west of York. There he halted, mustered his forces, set them in array, gave orders for their taking rest, and set off alone for York, which he entered shortly after Tostig and Hadrada had left. Before sunrise Harold spurred into Wharfedale and bade the army march towards the rendezvous for the hostages, Stamford Bridge. With Monday's dawn Hadrada, too, was stirring. Tall of stature, fair of face, strong of body, majestic of mien, he shook his bright lion-brown locks in the glowing morning air, and jauntily, as towards certain triumph, left the ships. His army was merry; they had shields, helmets, and spears, swords in their belts, and many had bows and arrows; but defensive armour they heeded not, they needed not. Their gaiety and gladness were great. So easy had been their winning of England. A dun dust, whirling in the wind, darkened the way in front, and out of the gloom lance-points and *albornos* (coats of mail) seemed to gleam. Hadrada halted and asked Tostig who these might be. "Likeliest foemen, though they may be friends," said he. The sunbeams brightened their "byrnies" and Tostig knew his brother Harold's host. "Let us, sire," said Tostig, "take to our ships with all speed for shielding, and let us be near them while we withstand this host of Saxon horsemen." "No hostile host," said Sigurd's son, "shall ever say they saw Hadrada hasten from a fray." He sent speedy horsemen to bring up his sailors from their ships, set up his banner Landeyda on the field, and arranged his army in array—a circle within a circle, shield locked within shield, his bowmen and body-guard standing inside the hollow, while the outer row held their spear-butts on the ground with their points horse-breast high. Hadrada rode round the shield-serried ring on a black steed, having a blaze of white on its forehead. His horse stumbled: he was thrown off. Harold saw the mishap and exclaimed—"Luck leaves the man who falls." He offered Tostig one-third of his kingdom if he made peace. "And what," said he, "will my brother give Hadrada?" "Seven feet of English earth, or seeing he is so

tall, a little more," was the reply. "Go, brother, busk for battle; Tostig will not betray trust." Harold rode back. Who was yonder man, and what wished he? inquired Hadrada. "The king, proffering me peace and great power," replied he. "Harold," said his namesake, "ought never to have had chance of causing our men's death." "I would sooner suffer

Norman Knight in Armour.

death at my brother's hand, in fight, than deal him a deathblow in perfidy." "Ha!" said Hadrada, "that was a smart man, and he stood well in his stirrups."

Harold ordered his cavalry to dash at once on the shield-serried, spear-girt ranks of Norway. The Saxon horse recoiled from the unflinching ring. The Norwegians, bursting from their close-locked circle, pursued the retreating cavalry. Harold rallied them, and they rushed on the confused mass of Hadrada's forces. He made onslaught on the English, dealing deathblows at every stroke. Suddenly a random arrow struck Hadrada in the throat, a gurgle was heard, a purple flow was seen, the jugular vein had been pierced, and energy and life ebbed rapidly. His death maddened the Norwegians. Tostig flew to the fluttering Landeyda, and underneath it directed the passion-stirred mass. Exhaustion overpowered both armies. They halted for breath-taking. Harold sent, offering peace and safety. War-wearied though they were, they uttered shouts of scorn and rushed to wreak vengeance upon their foes. Tostig fell in the throng of the struggle, and all seemed lost, when Eystein the Gorcock brought up the reserves from the ships, and renewed ardour nerved the assailants. Hadrada's host at length fled to their boats, leaving even their sovereign's body on the fatal field, and Harold's Thingmen pursued them hotly. A few resolute Norwegians, after seeing their companions across Stamford Bridge, manned the narrow roadway and defied the onset of the Saxons. The sturdy carles were swept down till only one was left. By his single sword no less than forty perished; but at length a Saxon, taking a boat, went under the bridge, and through a shrinkage in the planks pierced him with a spear. The men who came with a thousand ships left the shore in twenty-four, and for years unburied bones whitened the field of fight. The writer of one of the lives of Edward the Confessor breaks into elegiac verse, and mourns this complete defeat:—

"Who shall sing of vast Humber swollen into sea-like rage,
Where in fierce warfare met the namesake kings?
Or how, with barbaric blood, for miles the sea ran red,
While the sad North wept at the fearful woe!"

Harold began to bury the dead. Amid the wreckage of war was found Hadrada's treasure-chest, heavier in golden spoil than twelve men could lift. He was rejoicing in success and happy in the hope of the Festival of Peace shortly to be holden in York. A messenger, in hot haste, spurred into the camp-like city, bringing the tidings that on Michaelmas eve Duke William of Normandy had landed at Pevensey with 60,000 men, and built a castle-like encampment at Hastings, and were plundering the country round. Immediately Harold resolved, sadly lessened though his numbers were, to march southward with his Anglo-Saxon heroes. He reached London, and occupied six days there in raising the national militia of the seaboard. Before they could be collected, with the levies of Kent, Essex, and East Anglia, the king moved towards Bulverhithe. On 13th October he came in sight of the invader's position. Along the steep brow of a long hill at Senlac, Harold arrayed his forces, raising a stockade in front of his lines to break the charge of William's cavalry. On the hill-top, beside a hoary apple-tree, Harold pitched his banners—the *Golden Dragon* of Wessex and the *Fighting Man.* Round their watch-fires the English sat or lay feasting; the Normans, under Odo of Bayeux, prayed, confessed, and rested. William offered single combat to Harold. Harold rejected the suggestion. The Norman army, on 14th October, 1066, about eight, reached Senlac. William had proclaimed that he came to claim rights sanctioned by the pope, and announced that all who opposed him were "excommunicate." This dismayed many. Gurth and Leofwin, his brothers, appealed to Harold to depart from the fray and leave them—who were free from any oath—to defend the land, adding that then he could gather the levies and send them forward, or, if they were sore beset, he might lead them up, maintain the fight they were engaged in, and repel the Normans. Harold averred that his sense of duty prevented him from laying risks on others which he did not share. He trusted in the justice of his cause and the courage of his soldiery. He determined to hazard battle.

William rode a fine Spanish horse from St. Jago; his standard, blessed by the pope, was carried beside him by Toustain the Fair. His army was arranged in three columns of attack, and before he gave the word, he exhorted the host to fight valiantly, promised that they would share in the spoil gained, and averred he sought only his due. The war cry was *Dieu aide!* ("God to our aid!")

The English, shield knit to shield, held the hill-ridge, the men of Kent in the front, the burghers of London, the king's body-guard. Under the royal standard stood Harold, Gurth, and Leofwin, and the bravest Saxon thanes. To the Norman war-word they replied, "By the holy rood of Christ!" Norman archers and crossbowmen attacked the Saxon line, cavalry charged against it, and for hours the steady, close, shield-linked mass stood compact and solid. A great tall Norman, Taillefer ("Hack-iron"), began the attack fiercely, singing the song of Roland the Paladin, and butting against two Saxons, slew them before he himself was killed. Two inoperative onsets had been made, and the Normans bore back chagrined and disheartened. A rumour went out that the duke had fallen. He threw up his visor to show the ranks that he was still alive, and rallied them for a fresh rush against the living ramparts on the hill. He fought his way in to the royal standard with a few of Normandy's best around him; Gurth slew his horse with a spear, and fell by a swordcut from the falling rider. Leofwin was also slain; but the daring band was driven into a deep trench, where horse and rider fell pell-mell one on the other. It was now seven hours since the morning's march, and yet Saxon subbornness retained superiority. Strength, William thought, must yield to strategy. He ordered his archers to shoot high in the air, so that their arrows might fall like iron-hail into the midst of the cohorts. Many were wounded, and a trace of faltering was shown. William commanded a thousand horse to rush against the line, and to fall back in apparent

confusion and retreat. The English were taken by this snare. They rushed headlong after the foe, who were joined by another thousand horse, and then, facing about, assailed the Saxons, quite unprepared for such an event, in their disordered state. The Saxons could not retreat, they would not surrender, and hundreds of them fell by lance and sword. Several fought valorously amidst a host, cleaving the casques and mail of the enemy with their battle-axes. This feint, which had succeeded so well, was repeated, and when the embattled circle was at length by this means seriously broken the Normans rushed impetuously into the inclosure, and dealt death direfully on the scattered Saxons. Once again, even then, the Saxons renewed their encircling rampart, inclosing their king within their line. He had been active, brave, and watchful all the day, and a gleam of hope brightened his eye as he saw the reunited ranks of his heroic defenders. Just at this moment an arrow, flashing through the air, pierced Harold's left eye, and penetrated into the brain. Dismay paralyzed them, as their sovereign fell dead in their midst. Round the royal standard the Saxons rallied, and sought to defend it. Twenty Norman knights undertook to seize it. Ten fell before it was taken. The banner consecrated by the supreme pontiff was raised in its stead. When the sun set the Normans were masters of the field. The English troops, disheartened and scattered, were chased in the moonlight, but every now and then, turning at bay, made large drains on the blood of their victors. One-fourth of the host William had brought into action found their death-beds on and around Senlac hill, subsequently called *Battle*.

Defence of the Saxon Royal Standard.

Edith Swanneck, who, along with many women, came to seek among the slain the bodies of those they loved, found Harold's corpse, sadly disfigured, under a heap of dead. Under a stone cairn on Hastings Cliff William had the heroic Harold buried; but afterwards, granting the prayer of the monks of Waltham, he gave it them for nobler entombment. They took the corpse, but no man knoweth where the sepulchre of the last of the Saxon sovereigns is. Edwin and Morcar having reached London heard the news of the battle. While William was yet in his camp doing funeral honours to the brave, they assembled the Witenagemote and chose Edgar Atheling, Edward's nephew—whose claims had, as being but a child, been passed over in favour of Harold—as England's king. When Duke William was ready to move, having gathered his troops around him and gained many accessions, England saw that resistance was hopeless, for no nation could bear the desperate despoil of heroes which had taken place therein, twice within three brief weeks, and still withstand such an invader, for in these fiercely-fought battles full 50,000 Saxon soldiery were slain. When, therefore, they found that William and his followers plundered all they overran, Aldred of York, Edgar Atheling, Morcar, and Edwin, somewhat sulkily, surrendered to him under pressure of necessity.

William accepted their submission, and on Christmas Day, when Aldred solemnly crowned him king, he swore that he would "govern this nation as well as any king before him had best done, if they were faithful to him." At first his rule was liberal, but frequent attempts at rebellion afforded pretexts for rigour. He dispossessed the Saxon nobility of their estates, laid severe levies on the cities, reimposed the *Danegelt*, harried 60 miles between York and Durham, sacrificed by his severity 100,000 lives, and while he divided large land-holdings to his followers he retained in his own hand 1400 royal manors. He required to return to Normandy. In his absence the Saxons revolted, and aided by the Danes and Scots seized York. They were reduced, and Waltheof, earl of Northampton, was beheaded, because, knowing their design, he did not inform him of the plot. William deposed Stigand and appointed Langfranc archbishop of Canterbury, enforced homage from Malcolm III. of Scotland, who had married Margaret, sister of Edgar Atheling; and compelled Hereward, "the last of the Saxons" who maintained his independence, to submission. Many of the insurgents against his rule fled to Constantinople, entered the service of the Greek Emperor Alexis Comnenus, and crossed swords with their ancient Norman foes in the battle of Durazzo. Denmark having threatened an invasion William summoned a great national council, and proposed a complete change in the land-tenure of England. He claimed direct dominion over the whole territory, divided it into 60,000 fiefs, to the possession of each of which there was annexed the necessity of rendering military service during forty days in each year. Then (1085) was established the *feudal system* in England, and a general Domesday Book, or Register of Landed Property, was prepared, after actual survey, to regulate fiscal, administrative, legislative, and warlike measures. Thirty miles around Winchester were cleared—twenty-six villages and several convents and churches being destroyed in the process—to form the New Forest chase or king's hunting ground. For the safety of households from risk of fire, as well as for police purposes, the Conqueror introduced the *curfew*—the tolling of a bell at eight at night to warn all householders to hurry indoors and extinguish their fires.

In 1076 William invaded Brittany, where Ralph de Gueder had taken refuge; but Philip I. defeated the invader at Dol. Robert, William's son, in 1079 claimed the duchy of Normandy. They met on the battlefield of Gerberry, where the father was wounded by his son. They were afterwards recon-

ciled. Philip had seized the Vexin district, and had jested coarsely concerning William's grossness of body. William resolved on redress and revenge. He marched on Mantes, and as he rode round that city, which he had ordered to be put to fire and sword, his horse, treading on a burning stake, stumbled and threw him against the pommel of his saddle. He was seriously hurt—a lingering inflammation ensued—he was removed to the monastery of St. Gervaise, in the village of Hermantrude, outside of the walls of the city of Rouen; there, preparing himself for death, he languished for six weeks. He had always professed Christianity, and he surrounded himself now with all the external apparatus of holy dying—priests, bishops, and confessors. His two sons, William and Henry, were in attendance. Robert, the eldest, was at the court of France. His right to the crown of Normandy William could not annul, though he wished ill-luck to him in his inheritance. Of England, he said he had come into possession of it by so many evil deeds that he dared not leave it to any one except God; "by whose will," he added, "I trust that my son William may be king after me and reign gloriously." He then recommended an instant journey to England to William, in order that he might secure the throne. He left to Henry Beauclerc £5000, bidding him trust in the Lord that all that had been his father's he should gain and hold. He forgave his enemies, set free all state prisoners, commended his soul to God's grace, and awaited the end. On 9th September, 1087, the cathedral bell of Rouen rang out the hour of *prime*. "What does that bell mean?" cried William, starting suddenly up. They told him, and while yet the sounds were in his ears he expired. His body was carried for burial to St. Stephen's Abbey at Caen. There it was met by Prince Henry and a procession of monks. A fire broke out in Caen. The attendants on the obsequies fled, and only returned when the threatened conflagration was suppressed. After the knight Anselm Fitzarthur, whose property the Conqueror had seized as a site for the abbey, had been paid for the grave into which all that was mortal of him should be laid, the funeral of William was completed.

THE GREEK LANGUAGE.—CHAPTER IV.

PRONOUNS—THEIR DIFFERENT SORTS—THEIR INFLEXIONS.

PRONOUNS are the signs of personality. Everyone feels himself separated from what exists around him, and what surrounds him he regards as objects to be addressed, or to be thought of and spoken about. If that person thinks or speaks of himself alone the pronoun he uses as a sign for himself is singular; if he joins to himself another in thought or in speech he denotes that by the dual; if he joins several with himself the sign requires to be in the plural. As pronouns are mere signs of personality they may be used for and applied to any person or object in accordance with their use and meaning.

The old Greek grammarians gave the name of articles to two simple adjective-like words which are used in connection with nouns occurring in the same proposition, and having a relation of reference one to the other. For example in the sentence *ούτος έστιν ὁ ἀνηρ ὁς σωσει ἡμας*, This is the man who will save us, these two words *ὁ* and *ὁς*, as it were, coarticulate or join together in the mind the noun as the agent, and the relative which shows that agent as an actor by means of the verb. In the progress of language, and of the abbreviations found necessary or advisable in speech, men began to retain in their mind and to take for granted in their conversation or writing any reference which was sufficiently implied by circumstances or previously defining statements. In this way the idea of articulation was retained in the former under the name Article, and that of relation was denoted as belonging to the other in the designation of the Relative. These the old grammarians called the pre-positive and the post-positive articles, and both were really in earlier times quite alike in *form*. They are even yet very closely alike, and may be most conveniently presented—as regards their declensions—to the eye of the student side by side, as in the following co-ordinate paradigm:—

	Article, ὁ, ἡ, το, the.			Pronoun, ὁς, ἡ, ὁ, who, which.		
Singular.						
	Masc.	Fem.	Neut.	Masc.	Fem.	Neut.
Nom.,	ὁ,	ἡ,	το.	ὁς,	ἡ,	ὁ.
Gen.,	του,	της,	του.	οὑ,	ἡς,	οὑ.
Dat.,	τῳ,	τῃ,	τῳ.	ᾡ,	ᾑ,	ᾡ.
Acc.,	τον,	την,	το.	ὁν,	ἡν,	ο.
Dual.						
N. A.,	τω,	τα,	τω.	ὡ,	ἁ,	ω.
G. D.,	τοιν,	ταιν,	τοιν.	οἱν,	αἱν,	οἱν.
Plural.						
Nom.,	οἱ,	αἱ,	τα.	οἱ,	αἱ,	ἁ.
Gen.,	των,	των,	των.	ὡν,	ὡν,	ὡν.
Dat.,	τοις,	ταις,	τοις.	οἱς,	οἱς,	οἱς.
Acc.,	τους,	τας,	τα.	οὑς,	ἁς,	ἁ.

It may be remarked that these two words are declined precisely alike, except that the latter rejects the initial *τ* wherever it occurs.

The compounds of *ὁ, ἡ, το* are *ὁδε, ἡδε, τοδε; ὁγε, ἡγε, τογε*, this, that.

The compounds of *ὁς, ἡ, ὁ* are *ὁσπερ, ἡπερ, ὁπερ*, who, which; and *ὁστις, ἡτις, ὁ τι*; the indefinite *ἀλλος*, , *ο*, other; and the demonstratives *αὐτος, η, ο; ἐκεινος, η, ο*; he, she, it; that.

Pronouns are distinguished into Personal, Possessive, Relative, Adjective, Demonstrative, Reflexive, and Indefinite.

(1) There are three *Personal Pronouns*, *ἐγω*, I; *συ*, thou; and *οὑ*, of him, which are declined thus:—

Singular.			
Nom.,	ἐγω,	συ,	—
Gen.,	ἐμου μου,	σου,	οὑ.
Dat.,	ἐμοι μοι,	σοι,	οἱ.
Acc.,	ἐμε με,	σε,	ἑ.
V.,	—	συ,	—
Dual.			
N. A.,	νωι νῳ,	σφωι σφῳ,	σφωε σφω.
G. D.,	νωιν νῳν,	σφωιν σφῳν,	σφωιν.
Plural.			
Nom.,	ἡμεις,	ὑμεις,	σφεις σφεα.
Gen.,	ἡμων,	ὑμων,	σφων.
Dat.,	ἡμιν,	ὑμιν,	σφισι σφι(ν)
Acc.,	ἡμας,	ὑμας,	σφας σφεα.
V.,	—	ὑμεις,	—

The dialectical peculiarities of the pronouns are very numerous, and cannot be adequately dealt with here. It may be stated generally that deviations of a dialectical sort are similar to those made in the case-endings of nouns of the first and second declensions.

(2) The *Possessive Pronouns* are derived from the personal pronouns, and are regular adjectives of the first and second declension. They are

Masc.	Fem.	Neut.
ἐμ-ος,	-η,	-ον, mine.
νωιτερ-ος,	-α,	-ον, of us two.
ἡμετερ-ος,	-α,	-ον, our.
σος or τεος,	ση or τεη,	σον or τεον, thine.
σφωιτερ-ος,	-α,	-ον, of you two.
ὑμετερ-ος,	-α,	-ον, your.
ἑος or ὁς,	ἑη or ἡ,	ἑον or ὁν, his own.
σφετερ-ος,	-α,	-ον, their.

These pronouns are probably formed from the inflected cases of the personal pronouns, except *νωιτερος*, of us both, and *σφωιτερος*, of you both, which are derived from *νωι* and *σφωι*. They are only used by the Ionic poets, and that rarely.

(3) The *Relative Pronoun*, *ὁς, ἡ, ὁ*, who, which, has been already declined. It is a regular Adjective of the First and

Second Declension, except that it has ο in the Nominative and Accusative Singular Neuter.

The compound Relative ὅστις is declined with all the variations of the simple Relative ὅς, and of the Interrogative τις.

τις, τις, τι, who? which? what? ὅστις, ἥτις, ὅ,τι, who, which, whoever, whatsoever.

Singular.

	Masc.	Fem.	Neut.	Masc.	Fem.	Neut.
Nom.,	τις,	τις,	τι.	ὅστις,	ἥτις,	ὅ,τι.
Gen.,	τινος,	τινος,	τινος.	οὗτινος,	ἧστινος,	οὗτινος.
Dat.,	τινι,	τινι,	τινι.	ᾧτινι,	ᾗτινι,	ᾧτινι.
Acc.,	τινα,	τινα,	τι.	ὅντινα,	ἥντινα,	ὅ,τι.

Dual.

N. A.,	τινε,	τινε,	τινε.	ὥτινε,	ἅτινε,	ὥτινε.
G. D.,	τινοιν,	τινοιν,	τινοιν.	οἵντινοιν,	αἵντινοιν,	οἵντινοιν.

Plural.

N. V.,	τινες,	τινες,	τινα.	οἵτινες,	αἵτινες,	ἅτινα.
Gen.,	τινων,	τινων,	τινων.	ὧντινων,	ὧντινων,	ὧντινων.
Dat.,	τισι,	τισι,	τισι(ν).	οἷστισι,	αἷστισι,	οἷστισι(ν).
Acc.,	τινας,	τινας,	τινα.	οὕστινας,	ἅστινας,	ἅτινα.

Similarly the Indefinites οὔτις and μητις, no, no one, none, are declined.

τίς, with the acute accent, is Interrogative, who? which? what? With the grave (τὶς), or as enclitic without the accent, it is Indefinite, meaning someone, something.

(4) The *Adjective Pronouns* are—αὐτος, αὐτη, αὐτο, he himself; ἀλλος, ἀλλη, ἀλλο, another of many.

αὐτος is declined like a regular adjective, except that the nominative and accusative neuter end in -ο, not -ον, and the vocative is wanting. αὐτος has the signification of self (*ipse*) in the nominative case, and when joined in agreement with a substantive; but when it stands alone (*i.e.*, without the article or a substantive) it answers to he, her, it (*is, ea, id*); ὁ αὐτος signifies the same (*idem*).

The meaning of αὐτος varies with the position of the article, *e.g.*, αὐτος ὁ βασιλευς, the king himself; ὁ αὐτος βασιλευς, the same king; αὐτη ἡ ἀρετη, virtue itself; ἡ αὐτη ἀρετη, the same virtue.

Singular.

	Masc.	Fem.	Neut.
Nom.,	αὐτος,	αὐτη,	αὐτο.
Gen.,	αὐτου,	αὐτης,	αὐτου.
Dat.,	αὐτῳ,	αὐτῃ,	αὐτῳ.
Acc.,	αὐτον,	αὐτην,	αὐτο.

Dual.

N. A.,	αὐτω,	αὐτα,	αὐτω.
G. D.,	αὐτοιν,	αὐταιν,	αὐτοιν.

Plural.

Nom.,	αὐτοι,	αὐται,	αὐτα.
Gen.,	αὐτων,	αὐτων,	αὐτων.
Dat.,	αὐτοις,	αὐταις,	αὐτοις.
Acc.,	αὐτους,	αὐτας,	αὐτα.

(5) The *Demonstrative Pronouns* are, οὗτος, generally equal to this, that (*iste*), ὅδε, ἥδε, τοδε (*hic*), and ἐκεινος, η, ο (*ille*). The article ὁ, ἡ, το was originally a demonstrative; αὐτος is sometimes a demonstrative. οὗτος, this, is compounded of the Article and αὐτος, and proceeds by a very irregular inflection, thus:—

οὗτος, αὑτη, τουτο, this.

Singular.

	Masc.	Fem.	Neut.
Nom.,	οὗτος,	αὑτη,	τουτο.
Gen.,	τουτου,	ταυτης,	τουτου.
Dat.,	τουτῳ,	ταυτῃ,	τουτῳ.
Acc.,	τουτον,	ταυτην,	τουτο.

Dual.

N. A.,	τουτω,	ταυτα,	τουτω.
G. D.,	τουτοιν,	ταυταιν,	τουτοιν.

Plural.

	Masc.	Fem.	Neut.
Nom.,	οὗτοι,	αὗται,	ταυτα.
Gen.,	τουτων,	τουτων,	τουτων.
Dat.,	τουτοις,	ταυταις,	τουτοις.
Acc.,	τουτους,	ταυτας,	ταυτα.

Its compounds τηλικουτος, so large; τοιουτος, such; τυννουτος, and τοσουτος, αυτη, ουτο, so great, are declined similarly, but reject τ throughout, and sometimes make the Neuter in ον.

ὁδε, ἡδε, τοδε, this, that.

Singular.

	Masc.	Fem.	Neut.
Nom.,	ὁδε,	ἡδε,	τοδε.
Gen.,	τουδε,	τησδε,	τουδε.
Dat.,	τῳδε,	τῃδε,	τῳδε.
Acc.,	τονδε,	τηνδε,	τοδε.

Dual.

N. A.,	τωδε,	ταδε,	τωδε.
G. D.,	τοινδε,	ταινδε,	τοινδε.

Plural.

Nom.,	οἱδε,	αἱδε,	ταδε.
Gen.,	τωνδε,	τωνδε,	τωνδε.
Dat.,	τοισδε,	ταισδε,	τοισδε.
Acc.,	τουσδε,	τασδε,	ταδε.

The Greeks generally used the article with οὗτος (this), and ἐκεινος (that). The usual form was that the pronoun either preceded the article, or followed the substantive, thus: οὗτος ὁ, this the; ἐκεινος ὁ, that the; *e.g.* ταυτης της πολεως, or της πολεως ταυτης.

ἐκεινος, η, ο (formed from the adverb ἐκει, there), that there, or he, she, it (*ille*), is inflected like αὐτος. When it is opposed to οὗτος, it means that person or object. οὗτος, this person, &c. The semi-pronoun ἀλλος, -η, -ο, another (*alius*) is also inflected like αὐτος (see 4).

(6) There are three *Reflexive Pronouns.* They are compounded of the accusatives singular of each of the three personal pronouns and the oblique cases of αὐτος (self); thus—

Ἐμαυτου, of myself.

	Singular.		*Plural.*	
N.	(ἐγω αὐτος),	(ἐγω αὐτη).	ἡμεις αὐτοι,	ἡμεις αὐται.
G.	ἐμαυτου,	ἐμαυτης.	ἡμων αὐτων,	ἡμων αὐτων.
D.	ἐμαυτῳ,	ἐμαυτῃ.	ἡμιν αὐτοις,	ἡμιν αὐταις
A.	ἐμαυτον,	ἐμαυτην.	ἡμας αὐτους,	ἡμας αὐτας.

Σεαυτου, of thyself.

Singular.

N.	(συ αὐτος),	(συ αὐτη).
G.	σεαυτου or σαυτου,	σεαυτης or σαυτης.
D.	σεαυτῳ or σαυτῳ,	σεαυτῃ or σαυτῃ.
A.	σεαυτον or σαυτον,	σεαυτην or σαυτην.

Plural.

V.	ὑμεις αὐτοι,	ὑμεις αὐται.
G.	ὑμων αὐτων,	ὑμων αὐτων.
D.	ὑμιν αὐτοις,	ὑμιν αὐταις.
A.	ὑμας αὐτους,	ὑμας αὐτας.

Ἑαυτου, of himself.

Singular.

N.	(αὐτος),	(αὐτη),	(αὐτο).
G.	ἑαυτου or αὑτου,	ἑαυτης or αὑτης,	ἑαυτου or αὑτου.
D.	ἑαυτῳ or αὑτῳ,	ἑαυτῃ or αὑτῃ,	ἑαυτῳ or αὑτῳ.
A.	ἑαυτον or αὑτον,	ἑαυτην or αὑτην,	ἑαυτο or αὑτο.

Plural.

N.	(σφεις αὐτοι),	(σφεις αὐται),	(σφεα αὐτα).
G.	ἑαυτων or αὑτων,	ἑαυτων or αὑτων,	ἑαυτων or αὑτων.
D.	ἑαυτοις or αὑτοις,	ἑαυταις or αὑταις,	ἑαυτοις or αὑτοις.
A.	ἑαυτους or αὑτους,	ἑαυτας or αὑτας,	ἑαυτα or αὑτα.

The definite article is kept separate for the clearer marking out of the persons; as ἐγω αὐτος, or αὐτος ἐγω, I myself; συ αὐτος, you yourself; ἡμεις αὐτοι, we ourselves, &c. Also, σφων αὐτων, σφισιν αὐτοις, &c.

(7) The *Indefinite* negative pronouns are—οὐτις, μητις, no one; οὐδετερος, μηδετερος, none of the two, neither, neuter.

The pronominal compounds of εἱς, οὐδεις, οὐδεμια, οὐδεν, and μηδεις, μηδεμια, μηδεν, no, none, not even one, are inflected like the simple numerals εἱς, μια, ἑν, in the singular, and have the dual and plural regular. They are often written separately, thus—οὐδε εἱς, and μηδε εἱς, &c. Thereby their negative signification is intensified.

The Reciprocal ἀλληλοιν, &c., of one another, is formed from ἀλλος. It is used only in the oblique cases of the dual and plural numbers, and is thus declined:—

	Dual. Masc.	Fem.	Neut.	*Plural.* Masc.	Fem.	Neut.
G.	ἀλληλοιν,	-αιν,	-οιν.	ἀλληλων,	-ων,	-ων.
D.	ἀλληλοιν,	-αιν,	-οιν.	ἀλληλοις,	-αις,	-οις.
A.	ἀλληλω,	-α,	-ω.	ἀλληλους,	-ας,	-α.

A Reciprocal pronoun implies that each person executes the act on the other.

The Interrogative pronouns are τις, τις, τι, who? which? what? ποιος, α, ον, of what nature? of what sort? (generally implying surprised anger); ποσος, of what value? at what price? how far? and ποτερος, whether (of two)?

'Αμφω, both (of individuals, armies, nations, interests, &c.), is declined only in the Dual; N., A., V., ἀμφω; G. and D., ἀμφοιν. It is sometimes joined with a plural verb.

Among the pronouns may be classed the Indefinite δεινα, such an one, what's his name? &c. (when one cannot or will not mention the name). It has always the article prefixed, and is probably nothing else than a contraction of ὁ δε εἱς, του δε ἑνος, &c. It is sometimes indeclinable.

Singular.

	Masc.	Fem.	Neut.	
Nom.,	ὁ,	ἡ,	το	δεινα.
Gen.,	του,	της,	του	δεινος.
Dat.,	τῳ,	τῃ,	τῳ	δεινι.
Acc.,	τον,	την,	το	δεινα.

Plural.

Nom.,	οἱ,	—	—	δεινες.
Gen.,	των,	—	—	δεινων.

There are two indeclinable pronouns used for the accusative singular and plural of all genders, viz. μιν and νιν—the former by the Ionic writers in general and the Attic poets, the latter by the Attic poets only. The poets also use σφε.

There are three pronouns *patrial* that refer to country or place. They are compounds of ἡμος, ὑμος, for ἡμετερος and ὑμετερος, and πος, from δαπεδον, the ground, the genitive being shortened into δαπος; as ἡμεδαπος, of our country, our countryman; ὑμεδαπος, of your country; ἀλλοδαπος, of a foreign country, &c.; ποδαπος, of what country? where born?

Besides these there are other pronouns used in pairs, as Interrogative and Responsive, Antecedent and Relative; such as

το, the.	ὁ, which?
τοιουτος, τοιος, of the kind.	οἱος, of which kind?
τοσουτος, τοσος, of the number.	ὁσος, of which number?
τηλικος, of the size.	ἡλικος, of which size?
ποιος, of what kind?	ὁποιος, of which kind?
ποσος, of what number?	ὁποσος, of what number?
πηλικος, of what size?	ὁπηλικος, of whatever size?
πηνικος, of what time?	ὁπηνικος, of what time?

These pronouns are called correlative because they have always a relative expressed or understood—in connection with which there is also an interrogative and indefinite pronoun.

Interrogatives are characterized by an initial π; this is changed in Responsive and Demonstrative pronouns into τ, and in Responsive and Relative ones into an aspirate. T. K. Arnold exhibits them simply in this tabular form:—

	Interrog.	*Indefinite.*	*Demonstrative.*	*Relative.*
(size)	ποσος	ποσος	τοσος	ὁσος
(quantity)			τοσοσδε	ὁποσος
			τοσουτος	
(quality)	ποιος	ποιος	τοιος	οἱος
			τοιοσδε	ὁποιος
			τοιουτος	
(age)	πηλικος	πηλικος	τηλικος	
(size)			τηλικοσδε	ἡλικος
			τηλικουτος	ὁπηλικος

He adds that adverbs form also a similar correlative series.

Interrog.		*Indef.* (Enclitics.)	*Demons.*	*Relat.* *Simple.*	*Comp.*
ποτε,	when?	ποτε	τοτε	ὁτε	ὁποτε.
που,	where?	που	—	οὑ	ὁπου.
ποι,	whither?	ποι	—	οἱ	ὁποι.
ποθεν,	whence?	ποθεν	(τοθεν)	ὁθεν	ὁποθεν.
πως,	how?	πως	(τως)	ὡς	ὁπως.
πη,	in what direction? how?	πη	(τῃ)	ῃ	ὁπῃ.
πηνικα,	at what time of the day?	—	τηνικα	ἡνικα	ὁπηνικα.

The correlative pronouns may take the conjunctions δη, δηποτε, and ουν in the sense of ever (*cunque*), and the enclitic περ; ὁστις δηποτε, whosoever; ὁσπερ, whoever, &c.

The following words may also be regarded as in some sort pronominal relatives and correlatives:—

ὁ, the man.	ὁς, who; or ὁστις, whosoever.
οὑτος, this man.	ὁς, who.
παντα, all things.	ὁσα, which.
πας, every one.	ὁστις, whosoever.
μεχρι τουδε, to this point.	ἐς ὁσον, up to which, or as far as.
παντοιος, of all kinds.	οἱος, whatever.

ENGLISH LITERATURE.—CHAPTER VI.

BALLADS—HAWES, BARKLAY, HARDYNGE, SKELTON—EARLY COLLECTIONS OF MISCELLANEOUS POETRY—PROSE WRITERS: BERNERS, WOODVILLE, LELAND, FABYAN, RECORDE, WILSON, BELLENDEN, CAVENDISH, STORER, ELYOT, MORE, CHEKE, AND ASCHAM.

BALLADS are the poetry of the people. They embalm the passionate and the picturesque of common life. Emotions naturally associate themselves with romance, and poetry is the expression of life quickened by earnestness of feeling. The lights and shadows of life and society, transfigured in the heart, issue thence in song, enrich the mind, refine the heart, and delight the imagination. From the earliest times, special fragments of experience have been taken up and polished into the pellucidness of poetic presentation. In this form they were carried over a whole land, and the minstrel who had most of them was welcome in city and village, at grange and farm, in hall and hostel. These short, simple, metrical stories, having in their incidents a living charm for the emotions, became popular everywhere. The elastic rhythm and ready resonance of the ballad aid the memory and adapt themselves to any theme. Primarily transmitted as they are by traditionary repetition and recitation, they rarely acquire, in the earlier ages of a nation, the fixed importance of literature. In the course of time, however, the interest and enthralment of the ballad attract attention and induce imitation. The simplicity of their language, the directness of their style, and the striking rapidity of their narrative, excite the admiration of those who possess the gift of artistic expression, and awaken emulation. Between the age of Chaucer and that of the next great creative English singer, Spenser, many ballads seem to have put into pithy phrase and jaunty melody some record of the familiar feelings, popular usages, striking incidents, favourite pastimes, and political prepossessions of the community. Of this popular peasant poetry, a large mass was unprinted, and even when printed the broadsides on which it appeared were seldom preserved longer than till the matter they contained was passed from letterpress to memory. Only occasionally are the efforts of those minstrels of the masses recoverable; though the labours and researches of antiquaries have resulted in the gathering together of numerous collections of singularly diverse specimens of these simple and perspicuous popular narrative poems, in which are embodied the legends, traditions, incidents, and recollections of social, national, or individual life. Of such a sort are the free, joyous, and manifold rhymes of

> "Bold Robin Hood and all his band—
> Friar Tuck, with quarterstaff and cowl,
> Old Scathelocke with his surly scowl,
> Maid Marian fair as ivory bone,
> Scarlet and Mutch and Little John,"

of which a collection was printed as "A Lytel Geste of Robin Hood," by Wynkyn de Worde, about 1495. Historical ballads like "Chevy Chase," "Sir Andrew Barton," "Fair Rosamond," "The Miller of Mansfield," "The Tanner of Tamworth," &c., are numerous; so, though, in that time, more sporadic, desultory, and unorganized than they afterwards became, were political satires, of which there were swarms and volleys. These songs were disseminated in a very curious manner. "They were," as James Hannay says, "scattered like thistle seed on the roadsides, to be picked up by passengers." Of the old jollity and rude humour of antique life in England a good many ballads survive. In 1554–55, under Philip and Mary, "Rimes and Ballades intending and practising thereby to move and stir seditions, discorde, dissentioun, and rebellyon," were interdicted and severely proceeded against. That such productions enjoyed great popularity is evident from the number of them which have been found copied into the note-books of collectors of good things, and which have been published under such editorship as that of Ramsay, Percy, Herd, Finlay, Scott, Jamieson, Motherwell, Aytoun, Bell, Laing, Chambers, Ebsworth, Child, &c.

The influence of the ballad made itself strongly felt on literature. Its romantic beauty, its pathetic tenderness, its singular simplicity of style, its earnest hero-worship, its power of seizing upon salient points, its brief proverbial moralizings, and its vivid realization of life, led bards to feel that poetry to be popular must deal largely with the infinite variety of human experience, and however complex the coil may be, it must be such as excites the human sympathies of the heart.

Stephen Hawes, the dates of whose birth and death have not yet been precisely discovered, but who flourished 1483–1512, proclaimed himself as a direct disciple of "the monk of Bury, flower of eloquence," anxious

> "To follow the trace and all the perfectness
> Of my master Lydgate."

He was descended from the Hawes of Hawes in the Bushes, Suffolk, and was a student of Oxford. He travelled through England, Scotland, and France, was one of the gentlemen of the chamber to Henry VII., by whom he was much esteemed for his facetious discourse. His chief work, "The Passe-tyme of Pleasure," was printed in 1517 by Wynkyn de Worde, who characterizes the author, in the preface, as "a man of a pleasantte witte and singuler learnynge, wherein thou shalt finde, at one tyme, wisdom and learnynge, with myrthe and solace." It is a long-drawn-out allegory, in which Grand Amour, walking in a meadow, comes to a cross way which showed on the right the "waye of contemplation," and on the left the "waye of worldlye dignitye." On the latter he set out, sat down to rest, slept, and next morning met Fame, environed with tongues of fire and accompanied by two greyhounds—Grace and Governance. At "the goodlye ladye" he inquired the way "unto the towre of famous Doctrine." Fame shows how influential she is, and gives him her greyhounds as guides to La Bel Pucell, in the tower of Countenance; "the goodly portress" leads him to Dame Doctrine, who sends him onward to Grammar. He goes thereafter to Logic, Rhetoric, Invention, Arithmetic, and Music. In the tower of Music he met La Bel Pucell, made love to her, and was "fairely entreated." He fared forth to Geometry and Astronomy. After leaving the tower of Science, he entered the hall of Chivalry. Here Minerva introduced him to Melyzyus. Then he went to the temple of Venus, who gave him a letter to La Bel Pucell. The giant Gobelive accosted him, and led him to the house of Correction. Perseverance brought him to Dame Comfort. Afterwards he married La Bel Pucell, and long lived happily with her. At last he was overtaken by Age, and was persecuted by Policy and Avarice. Death came with a summons to Grand Amour, and Remembrance wrote an epitaph on him. The poem includes two fabliaux from the French. All along its pilgrim's progress, through study, activity, gentility, suffering, and sorrow, the allegorical signification is very well kept up, with the design of enabling the author to command men to arise—

> "Out of your sleep of mortal heavinesse,
> Subdue the devil with grace and meeknesse,
> That after your life, frail and transitory,
> You may then live in joy perdurably.
>
> . . . .
>
> So, famous poets did us indoctrine
> Of the right way to be intellective;
> Their fables they did so right[ly] imagine,
> That by example we may 'void the strife,
> And without mischief for to lead our life,
> By the advertance of their stories old,
> The fruit whereof we may full well behold."

Hawes also wrote "The Exemplar of Virtue"—goodly stories and natural disputations between four ladies named Hardiness, Sapience, Fortune, and Nature—printed by Wynkyn de Worde, 1531; "The Delight of the Soul;" "The Consolation of Lovers;" "The Conversion of Swearers;" and, according to some authorities, "The Temple of Glasse," but Hawes attributes that poem to Lydgate, saying—

> "The tyme to passe
> Of Love, he made the bright Temple of Glasse."

In "A Controversy between a Lover and a Jay," by

Thomas Feylde, this writer is mentioned along with Chaucer, Gower, and Lydgate, thus:—

> "*Young* Stephen Hawes (whose soul God pardon)
> Treated of Love so clerkly and well,
> To read his works is mine affection,
> Which he compiled of La Bel Pucell,
> Remembering stories fruitful and delectable."

Alexander Barklay was, Dr. William Bulleyn informs us, in his "Dialogue, both pleasant and pitiful, wherein is showed a goodly Regimen against the Plague, with Consolations and Comforts against Death" (1564), "born beyond the cold river of Tweed." In 1495 he was a student of Oriel College, Oxford. He seems to have spent his early days near Croydon, in Surrey. On the Continent he acquired a knowledge of Dutch, German, Italian, and French. For the better diffusion of the last-named he issued "The Introductory to write and to pronounce French" (1521). Thomas Cornish, bishop of Tyne, patronized him, appointed him his chaplain and one of the priests of St. Mary at Ottery College. He is said to have passed from the order of St. Benedict to that of St. Francis, and when his monastery was dissolved to have been made vicar of Buddow Magna in Essex (1546), and subsequently also of the Church of St. Matthews at Wokey, Somersetshire. He was translated to the vicarage of All Saints, Lombard Street, London, 30th April, 1552, and a few weeks afterwards, having attained a great age, died at Croydon—his will having been proved 10th June, 1552.

Barklay added much to the copiousness of the English language, of which he was one of the refiners. He was admired for wit, learning, eloquence, and fluency. He translated some of the "Eclogues" of the Mantuan bard, also "The Wars of Sallust;" and, at the request of Sir Giles Alyngton, Knt., Dominic Mansini's "Mirror of Good Manners" for "the Juvent of England" from the Latin: and "The Castle of Love"—an allegorical poem showing how Lady Reason overcomes Despair, Poverty, &c., and leads on to Riches, Virtue, and Honour—from the French. When Barklay was a monk in Ely he translated and dedicated to Bishop West some "Lives of the Saints"—Margaret, Katharine, Etheldreda, George, Thomas, &c. "The Miseries or Miserable Lives of Courtiers," we presume, was a prose treatise, as was also "The Figure of our Mother Holy Church oppressed by the French King." Barklay's (fifty) "Eclogues" are the earliest specimens of that species of pastoral poetry in English. Their language is polished and their moral precepts high for the age, for example:—

> "Joy not in malice, that is mortal sinne;
> Man is perceived by language and doctrine;
> Better 'tis to lose, than wrongfully to winne;
> He loveth wisdom which loveth discipline;
> Rash enterprises oft bringeth to ruine;
> A man may contend, God giveth victory;
> Set never thy mind on that which is not thine;
> Trust not in honour, all wealth is transitory."

Barklay's most important addition to literature was, however, "The Shyppe of Fooles." By it, he greatly helped to impress grace and harmony on English verse The work is a translation "out of Latin, French, and Dutch," from the "Narrenschiff" (*Navis Stultifera*) of Sebastian Brandt, the satirical syndic of Strasburg, who led off the humour of the sixteenth century. It ridicules the vices of every rank and profession, under the allegory of a ship freighted with fools, to the number of 113, who came from all quarters, wading and even swimming to get on board. No one who suspects himself a fool is admitted, only those who imagine themselves to be wise. On each one a cap and bells are fitted. The author himself leads off as the book fool, who having too many books—books which he neither reads nor understands—still goes on buying more. Miser fools, dandy fools, old fools, ambitious fools, &c., are limned to the life. The original, written in the Alsatian dialect, was translated thence into Platt Deutsch and Latin, and transfused into High German and English. An incidental indication of Barklay's nationality appears in a long and laboured encomium on (*Jacobus*) James IV., whom he highly compliments for courage, prudence, and virtue. One of the stanzas contains this acrostic:—

> "*I*n prudense peerlesse is this most comely kinge,
> *A*nd as for his strength and magnanimitie,
> *C*oncerninge his noble deedes in everythinge
> *O*ne found on ground, like to hym cannot be.
> *B*y byrthe born to boldnesse and audacitie;
> *U*nder the bold planet of Mars, the champioun
> *S*urely to subdue his enemies eache one."

Barklay represents the ignorant bookworm self-descriptively saying—

> "Lo, in likewise, of bookés I have store,
> But few I reade and fewer understande;
> I follow not their doctrine nor their lore,
> It is enough to be a booke in hande;
> It were too much to be in such a lande
> For to be bound to looke within the booke,
> I were content on the fayre covering to looke.
> Still I am busy books assemblyinge,
> For to have plentie, it is a pleasant thinge,
> In my conceite to have them aye in hande;
> But what they mean I do not understande.
> But yet I have them in greate reverence
> And honour, savinge them from filth and ordure
> By often brushing and much diligence;
> Full goodlye bounde in pleasant coverture
> Of damask, sattin, or els of velvet pure;
> I keepe them sure, fearinge they should be loste,
> For, in them, is the cunning wherein I me boaste;
> But if it fortune that any learnede man
> Within my house fall to disputacion
> I drawe the curtaines to showe my bookes than,
> That they of my cunning should make probation;
> I love not to fail in altercation,
> And while they commune, my books I turne and winde,
> For all is in them and nothinge in my minde."

"The Shyppe of Fooles," although less graphic and humorous than Chaucer's "Prologue," may to a certain extent be regarded as holding a parallel place in regard to Barklay's age with poetical portraits of many of the characters then abounding, given with an intensifying touch of the ridiculous.

John Hardynge, who, in the opinion of Thomas Fuller, "had drunk as hearty a draught of Helicon as any in his age," wrote a "Metrical Chronicle of England, from the earliest times to the reign of Henry IV.," which, though laboriously compiled, forms remarkably unattractive reading unless it be regarded as a sort of chanting prose. He was of Yorkshire descent, served under the Percys, and fought under the banner of Harry Hotspur in the battle of Shrewsbury, and was himself eyewitness of some of those scenes of which he makes record.

John Caius (or Kaye), poet laureate to Edward VI., translated "The History of the Siege of Rhodes," but, perhaps fortunately for his fame, none of the poems of the king's versificator remain to prove his right to the laurel, although much could scarcely have been expected from a poor poet whose salary was fivescore shillings a year.

John Skelton, said to be descended from the Skeltons of Cumberland, was born about 1460, educated at Oxford, and became *Oxoniæ poeta laureatus*—perhaps prize-poet at the university. He was tutor to Prince (afterwards King) Henry (VIII.), and Erasmus regarded him as "the light and glory of British literature" in his time. Having taken holy orders, he was made rector of Dysse, in Norfolk; but having married—a crime at that time against ecclesiastical law—Richard Nykke, bishop of Norwich, suspended him from exercising priestly functions. His satiric poetry is a sort of hilarious jingle—nimble, sparkling, vivacious, powerful, reckless, and somewhat buffoonish. The language he uses is spirited, unrefined, and rattling, with a kind of tambourine rhythm about it which gives it jauntiness and effect. In 1498, he wrote "Verses on the Creation of Arthur, Prince of Wales," and in his "Garland of Lawrell," he claims that when he was Henry VIII.'s tutor,

> "A tretyse he devised and brought it to pass,
> Called "Speculum Principiis," to bere in hande,
> Therein to read, and to understande
> All the demeanour of princelie estate."

He composed elegies on the death of King Edward IV.

(1484), and on that of the Earl of Northumberland (1489). "A most moral interlude and a pithie," entitled "The Necromancer," was played before King Henry VII. and the "other estates," at the royal manor of Woodstock on Palm Sunday, 1594. It is a dramatic satire on the abuses of the church. The characters are a Necromancer, Satan, a Notary Public, Simony, and Greed. The two last-mentioned are brought to trial before Satan as judge, the notary acts as assessor, witnesses are examined, the prisoners are found guilty and ordered at once into dismal torment. Another "goodly and merry interlude," the moral purpose of which was to show the vanity of earthly grandeur, was probably composed for Henry VII. It is entitled "Magnificence." Its *dramatis personæ* are Felicity, Liberty, Measure (Moderation), Counterfeit Countenance, Crafty Conveyance, Cloaked Collusion, Courtly Abusion, &c. These shadowy characters speak about 2600 short rhymes. "The Bouge (bouche) of Court" is an allegorical pageant, in seven-lined stanzas, in which Riot, Dissimulation, Disdain, &c., are personified in hard, heavy, laboured, and serious verse. "The Boke of Colin Clout," is a roughly rhymed six-syllabled satire on the clergy. "Speake Parrot" is a piquant tirade in the Chaucerian stanza of seven lines. In it, Henry VIII. is satirized as Boho, and Cardinal Wolsey as Bough-ho—two dogs of the court of whom the parrot speaks his mind very freely. "Why come ye not to the Court?" is an exceedingly bitter attack on Wolsey, with whom he had been on terms of great friendliness when he wrote his "Goodly Garland or Chaplet of Lawrell." On account of these attacks the cardinal became exceedingly enraged at Skelton, and took measures for his apprehension. He, however, fled into sanctuary at Westminster, of which his old friend John Islip was abbot. There he probably remained till his death, 21st June, 1529. He was interred in the chancel of St. Margaret's, Westminster. While he was in sanctuary, Skelton employed himself in copying and collecting the epitaphs of the kings and royal personages buried in the Abbey, and in composing verses to their memories. Caxton in the preface to his "Æneid" (1490), notices "Mayster John Skelton, late created poete laureate, in the Universitye of Oxenforde, who hath latelie translated the Epystles of Tulle (Cicero), and the Boke of Diodorus Syculus, and dyvers other works, out of Latin into Englyshe." He composed numerous minor poems and ballads—one a coarse half-tipsy stave on "The Tunning of Eleanour Rummyng," who, he informs us, "dwelt in Sothray, in a certain street beside Leatherhead," about 8 miles from Nonsuch Palace. She was

"Ugly of cheer,
Her face all bowsy,
Wonderfully wrinkled,
Her eyen bleared,
And she gray-haired.
She breweth nappy ale,
And maketh thereof fast sale
To travellers, to tinkers,
To sweaters, to swinkers,
And all great ale drinkers."

And another a rather lively canzonette on Miss Margaret Hussey, the first part of which runs thus:—

"Merry Margaret,
As midsummer flower,
Gentle as falcon
Or hawk of the tower;
With solace and gladness,
Much mirth and no madness,
All good and no badness;
So joyously,
So maidenly,
So womanly
Her demeaning
In everything,
Far, far passing
That I can indite,
Or suffice to write,
Of merry Margaret."

"A Ballade of the Scottysche Kynge" [James IV.], on the Battle of Flodden, seems to have been written on the very first news being received, for the

"Special consolacion
Of all our loyal Englyshe nacion."

Catullus, in an elegy on the death of the sparrow of his mistress Lesbia, embodied in its lines more of the graceful and pathetic than are to be found in any equal number of verses in the Latin language. Though, perhaps, Skelton caught the original suggestion for his "Phyllyp Sparrowe" from the poetic lover of the sister of Clodius, he has not incorporated in it the graphic grace of the Veronese versifier. It is the sad bemoaning of Jane Scrope for her pet sparrow Philip, whom a cat has killed. He closes the poem with an epitaph in Latin on the slain pet, and lines in commendation of Miss Scrope. In the course of his rhyme he gives us the following opinion of the state of the English language in his time—

"Our naturall tong[ue] is rude
And hard to be enneude
With pollyshed termes lusty;
Our language is so rusty,
So cankered, and so full
Of forwardes and so dull,
That if I wolde applye
To wryte ornatély,
I wot not where to finde
Termes to serve my minde.
Gower's Englyshe is old,
And of no value told;
His matter is worth gold,
And worthy to be enrolled;
In Chaucer I am spede,
His "Tales" I have read;
His matter is delectable,
Solacious and commendable;
His Englyshe well allowed,
So as it is *emprowed*[=duly proved],
For as it is employed,
There is no Englyshe voyd,
At those days much commended,
And how would men have amended
His Englyshe, whereat they barke,
And mar all thy warke;
Chaucer that famous clerke,
His termes were not darke,
But pleasand, easy, and playne,
No words he wrote in vayne."

The oldest of our (printed) collections of miscellaneous poetry appeared 5th June, 1557. It bore the title of "Songes and Sonnettes, written by the ryght honourable Lorde Henry Howard, late Earle of Surry, and Other. Apud Richardum Tottel." It appeared *cum privilegio,* curiously enough, in the very heat of the Marian persecutions, when Cardinal Pole was archbishop of Canterbury, and its popularity was so great that it went through eight editions in thirty years. Herein were hived the best attainable products of the poets during the thirty years preceding its issue. In its pages are included forty poems by the Earl of Surrey, ninety-six by Sir Thomas Wyatt, forty by Nicholas Grimoald—chaplain to Thomas Thirleby, bishop of Ely, and (Arber conjectures) its editor—and one hundred and thirty-four pieces by other authors. Among these were Thomas Churchyard, who tells us in his "Challenge" (1593), "Many things in the booke of "Songes and Sonnettes printed then were of my making;" Thomas, second Lord Vaux of Harrowden; Edward Somerset, fourth earl of Worcester; John Heywood, the early dramatist; and Sir Francis Bryan, nephew of Lord Berners, and chief justiciary of Ireland, whom Michael Drayton mentions as having had "a share" in "these small poems," which contain "many passages of dainty wit." It has been conjectured that some of the "Rhythmi Elegantissimi" of George Boleyn, earl of Rochefort, and brother of the unfortunate Queen Anne Boleyn, have a place in this miscellany. Ritson assigns to him what Campbell calls "one of the most beautiful and plaintive strains of our elder poetry," "O Death rock me on Sleep." One of the Harrington MSS., reprinted as "Nugæ Antiquæ" (1804), expressly states that a very graceful and tender set of verses are due to his pen. They commence thus—

"My lute awake, performe the last
Labour that thou and I shall waste;
And ende what I have now begonne;
And when this song is sunge and past,
My lute be styll, for I have done."

Warton credits Sir Thomas More with the following pointed epigram, perhaps the earliest in our language:—

"A student at his booke so placed,
That wealthe he might have won,
From book to wife did flit in haste:
From wealthe to woe to run.

Now, who hath played a feater cast,
Since juggling first begun,
In *knitting* of himself so *faste*,
Himself he hath *undone*."

A sad memorial of the popularity of Tottel's miscellany may be mentioned. Mary Queen of Scots, when imprisoned in Fotheringay Castle, wrote, with a diamond, on a window there, the closing lines of the first stanza of one of the anonymous compositions in it, beginning—

"To this my song give eare who list,
. . . .
Ah from the top of all my trust,
Mishap hath thrown me in the dust."

The success of this miscellany speedily led to the issue of other collections of floating and fragmentary verse, such as Thomas Howell's "Arbor of Amitie," wherein is comprised pleasant poems and "prettie poesies," published in 1568. Howell modestly hoped that amid the storms of criticism—

"His hulk such port shall finde,
When storms be past, as will contente his minde."

One copy alone is known. It is in the quiet haven of the Bodleian Library. Next came "The Paradyse of Dayntye Devises" (1576), of which eight editions appeared in the next twenty-four years. It was edited by Richard Edwards, a Somerset man, student of Corpus Christi and of Christ Church, Oxford, where he became M.A. in 1547. He was a member of Lincoln's Inn, one of the gentlemen of Queen Elizabeth's Chapel, and master of the choir children there. He was an excellent musician, a poet, and a playwright. His "Damon and Pythias" was performed at the court and in the universities, and "Palamon and Arcite" before Queen Elizabeth, in Christ Church Hall, by the gownsmen of the university. He died 30th October, 1566. For "the most part," the title bears, the contents of the "Paradyse" were composed by Edwards; but verses by Edward Vere, earl of Oxford; William Hunnis, author of "Seven Sobs of a Sorrowful Soule for Sinne;" Jaspar Heywood, translator of three of the tragedies of Seneca; Lord Vaux, Francis Kynwelmersh, R. Hall, R. Hill, Lodowycke Lloyd, T. Marshall, Thomas Churchyard, D. Sand, E. G. M. Yloop, and some others, appear in it.

"The Gorgious Gallery of Gallant Inventions" (1578) was edited and in large measure composed by Thomas Proctor, author of a "Treatise of Heavenly Philosophy," and Owen Roydon, a fairly able rhymer of that time. "A Handfull of Pleasant Delites" (1584), but probably projected in 1566—as at that date "A Boke of Very Pleasaunte Sonnettes and Storyes in myter" is noted in the Stationer's Registers as by Clamant Robynson—contains, besides poems by the editor, verses by L. Gibson, R. Jones, G. Mannington, J. P(roctor), P. Picks, T. Richardson, J. Thomson, and others. "The Phœnix' Nest" (1593) is an attractive and interesting collection of seventy-nine dispersed verses, by several authors, such as Peele, Greene, Hodge, Watson, Breton, Sir William Herbert, &c., made by R. S. (of whose personality no certain knowledge has been gained). All these works show that there were poetical fancies afloat in the air, and men of poetic power among those who lived in the Tudor times.

Surrey, though not a great poet, was an influential one. To him we owe the introduction of a taste for the rhythmical music of Italian versification and bell-like intonations of the sonnet. He is at once chaste and delicate in thought, soft and ornate in style, select and simple in matter, and expresses the gentler passions in fine melodious cadences, though he cannot awake by his lyre the ruder and more potent of the energies of emotion. He was our first writer of (non-dramatic) blank verse. He added to illustrious ancestry the still nobler glory of genius and worth.

Sir John Howard was raised by Richard III. to the dukedom of Norfolk, and at the same time his son Thomas was created Earl of Surrey. On the fatal battlefield of Bosworth "Jockey of Norfolk" fell, and Henry VII. held the title as forfeit. To his son, however, the earldom of Surrey was restored in 1489, and when he had won Flodden, Earl Thomas was created Duke of Norfolk (1514). Ten years afterwards he died, and was succeeded by his son Thomas, who, by his second wife Elizabeth Stafford, eldest daughter of Edward, duke of Buckingham, became the father of the poet Henry Howard. He was born about 1516, and was brought up in infancy at Tindring Hall, in Suffolk. He was carefully trained under the care of John Clerke, author of a theological tractate in Latin, "On the Resurrection of the Dead and the Last Judgment" (1545), which is dedicated to his pupil, as well as a secular "Treatise of Nobility," dedicated to his pupil's father (1543). He was acquainted with Latin, Italian, French, and Spanish. In 1526 he was appointed cup-bearer to Henry VIII. He accompanied that king to the Field of the Cloth of Gold (1532), bore the fourth sword at the coronation of Queen Anne Boleyn (June, 1533), and was companion to the Duke of Richmond while studying in Paris. At Windsor also, as he tells us—

"With a king's son my childish years did pass."

Early in 1532 Surrey was contracted in marriage to Lady Frances Vere, daughter of John, earl of Oxford, and in 1535 the wedding took place. His eldest son Thomas was born 10th March, 1536. After the death (July, 1536) of Richmond, who had married his sister, Surrey set out on his travels through Southern Europe, conducting himself, Michael Drayton tells us, as "prince and poet (a name more divine)," and proving himself to be "the most learned among the nobility, and the most noble among the learned." He was one of the chief mourners at the funeral of Lady Jane Seymour in 1539, and in 1540 he jousted against Sir John Dudley, Sir Thomas Seymour, and others on the occasion of Henry's marriage with Anne of Cleves. When war broke out in 1542, between Henry VIII. and James V., Surrey, under his father's command, took part in the invasion of Scotland. Early next year he was confined in Windsor for eating flesh in Lent. In 1544 he was present as a volunteer at the siege of Laurecy, near Boulogne, and gained the highest praise from Sir John Wallop, the commander, for his skill and zeal in military matters. He was made marshal, and when Henry, who invested Boulogne in person, ordered the raising of the siege of Montreuil, Surrey conducted the retreat of the English, with consummate ability, in the face of famine and the French. Henry made him a Knight of the Garter, and in April, 1545, gave him command of the vanguard of a force intended to defend the English pale in France. In consequence of intrigues by the Hertfords he was recalled. He resented his supercession and was imprisoned. He was accused of bearing certain arms which belonged to the king, and was beheaded on Tower Hill, 19th June, 1547.

Besides the poems contained in Tottel's *Miscellany*, Surrey translated the first five chapters of Ecclesiastes, and several of the Psalms of David, into English verse. Induced, probably, by the example of Gawin Douglas, from whom he occasionally adopts a happy phrase, Surrey adventured to turn Virgil's Æneid into English. In this he used blank verse, of which his rendering of the second and fourth books constituted the earliest specimens in our language. He is notable as one who, as Camden says, "hath graced high birth with learning and travel, a man of various language, wit, and poetical fancy." Edmund Bolton, author of "Hypercritica" (1617), regards these songs and sonnets as "written in a noble, courtly, and lustrous English; and therefore the authors did, by writing of them, greatly polish our rude and homely manner of vulgar poesy from what it had been before, and [they] may therefore justly be esteemed the reformers of our English metre and style." He adds the opinion "that Surrey and Wyatt were the most noted poets of their time, and the most passionate of all English poets to bewaile and bemoane, in the said songs and sonnets, the perplexities of love," &c. In "The Arte of English Poesie" (1589), attributed to George Pultenham, they are spoken of as "the two chief lanterns of light to all others that have since employed their pens upon English poesy; their conceits were lofty, their style stately, their conveyance clearly, their terms proper, their metre sweet and well proportioned, all imitating very naturally and studiously their master—Francis Petrarch."

Thomas Wyatt, whom Anthony Wood characterizes as "the delight of the Muses and of mankind," was the son of Henry Wyatt, knight of Allington Castle, near Maidstone in Kent, and his wife Anne Skinner. He was born in 1503, and in 1515 entered St. John's College, Cambridge, where he became B.A. in 1518, and M.A. in 1522. He attended the lectures instituted at Oxford by Cardinal Wolsey, travelled through the south of Europe, and there became well skilled in military affairs, and also in several arts and tongues. On his return he was looked upon as the ornament of the court of Henry VIII. for personal beauty and mental endowments. He had married, prior to this period, Elizabeth, daughter of Thomas Brooke (Lord Cobham), who had, as he has said, "a face that would content me wondrous well," and to whom he was knit "with knot that should not slide." At court he and Henry—though both married, the one poetically and perhaps platonically, and the other powerfully and passionately—flirted for a time with Anne Boleyn; and when, on Whitsunday, 1st June, 1533, that lady was crowned as Henry's queen, Wyatt was present, acting, instead of his father, as chief ewerer, pouring perfumed water on her pretty hands. In 1535 Wyatt was, for some reason, a prisoner in the Tower; but on Easter Day, 1536, was knighted, and in September received a command in the army sent, under the Duke of Norfolk, to quell a rebellion against the suppression of the smaller monasteries in the shires of Lincoln and York. He was Henry's ambassador to the Emperor Charles V. during the years 1537–40, and seems to have discharged his duties with sagacity and ability. On his return, at the instigation of Bishop Bonner, Wyatt was arrested on a charge of holding treasonable correspondence with Cardinal Pole. He was tried, defended himself, was acquitted, and the king granted him lands in Lambeth, and made him high steward of the Manor of Maidstone, together with some estates in Devon and Somerset in exchange for some in Kent. Soon afterwards he retired to Allington, and devoted himself to producing "Certaine Psalms of David, commonly called Penitential Psalms, drawne into Englyshe meeter," by Sir Thomas Wyatt, Knight (1549), and ultimately "The Whole Psaltery of David." In the autumn of 1542 Charles V. sent ambassadors to Henry VIII. Wyatt was ordered to meet them at Falmouth, and bring them on to London. He overheated himself by overhaste in riding, and at Sherborne, in Dorsetshire, was seized with a fever, of which, after a few days' illness, he died, 11th October, 1542.

The following stanzas supply not only a pen-portrait of Wyatt, but a specimen of Surrey's verse:—

A visage stern and myld, where bothe did growe,
  Vice to contemne, in Virtue to rejoyce;
Amid great storms, whom grace assuréd so,
  To live upright and smile at Fortune's choyce.

A hand that taught what might be saide in rhyme,
  That reft Chaucére the glorye of his witte;
A marke the which (imperfected for time)
  Some may approache, but never none shall hit.

A tongue that served, in foreign realmes, his kinge,
  Whose courteous talk to Virtue did enflame
Eache noble heart, a worthy guide to bringe
  Our Englyshe youth, by travail, into Fame.

An eye whose judgment none affect could blinde,
  Friendes to allure and foes to reconcile,
Whose piercing look did represent a minde
  With Virtue fraught, reposéd, voyde of guyle.

A heart whose dreade was never so impressed
  To hide the thoughte that might the truth advance;
In neither fortune lost, nor yet represt,
  To swell in wealth or yield unto mischance.

A valiant corps, where force and beauty met,
  Happy, alas! too happy, but for foes;
Livéd and ran the race that Nature set
  Of manhoode's shape, when she the mould did lose.

John Bouchier, Lord Berners, born at Tharfield, Hertfordshire, in 1474, was educated at Baliol College, Oxford, travelled into many countries, and made himself master of many languages. He quelled a rebellion in Devon and Cornwall, was chancellor of the king's exchequer and warden of Calais, where he died 16th March, 1532. He wrote a drama, "Ite in Vineam Meam" ("Go ye into my Vineyard"), which was acted, after vespers, in the cathedral of Calais. He was noted as one who translated "with wonderful felicity" many works into excellent English prose:—"Froissart's Chronicles" (1326–1400), by special command of Henry VIII.; "Arthur of Little Britain" (Armorica), at the request of the Earl of Huntingdon; "Syr Huon of Bordeaux;" "The Castle of Love," from the Spanish, at the suggestion of Lady Elizabeth Carew; "The Golden Booke of Marcus Aurelius," at the instance of Sir Francis Bryan. As a scholar, a statesman, a soldier, and a far-travelled linguist of wide experience, Lord Berners was eminently qualified to enrich and enlarge the early prose literature of England.

The learning and intellectual tastes of John Tiptoft, earl of Worcester, an ardent lover of books, a man of military and political repute and considerable scholarship, led him to patronize Caxton, who published his translation of Cicero's "Treatise on Friendship." He was Constable of the Tower, and in the Tower he perished, at the instance of Warwick, under Henry VI., in 1470. "The axe then," as Fuller says, "did at one blow cut off more learning than was left in the heads of all the surviving nobility." Yet among these there was Anthony Woodville, Lord Seales and Earl Rivers, son of Sir Richard Woodville and his wife Jaquetta of Luxemberg. He was accomplished in all earthly graces, martial discipline, and intellectual culture, and not more by his being brother of Edward IV.'s queen than by his genius, was raised above nobles of lofty lineage. His translation of the "Dictes and Sayings of the Phylosophers" of Johan de Jeanville was the first book printed by Caxton at Westminster, 18th November, 1477. His "Boke named Cordyall or Memorare Novissimæ" was also a rendering from the French; but he produced "A Balet," in imitation of Chaucer. At Stoney-Stratford the whole of the Woodvilles were suddenly seized by order of Richard of Gloucester, hurried to Pontefract, and were there, in 1483, without trial or sentence, put to death, and

"Untimely smothered in their dusky graves."

"The Itinerary" of John Leland (1506–52) has more the character of a useful and agreeable road-book than of a literary work. It was begun in 1538, but remained unpublished till 1710.

Robert Fabyan was born and carefully brought up in London—Wood says he studied grammar and logic at Oxford. He became a wealthy merchant. He was an alderman of his native city, and was elected one of its sheriffs; but apparently to escape the mayoralty retired to Halstedye in Essex, where he died 28th February, 1512. His knowledge of Latin was then unexcelled. He wrote verses in Latin, French, and English, many of which he introduced into his prose narratives. He pursued historic studies with great zeal. His Chronicle, which he named "The Concordance of Hystoryes," is divided into seven periods; in six books he deals with the history of Britain (and France), from the landing of Brute to the Norman Conquest, and in the seventh he continues the record to 1485. He is somewhat dull and does not appreciate the perspective of history, giving with equal detail the monarchs of England and the mayors of London, the festivities of the corporations and the struggles of the country for freedom at home and influence abroad. Cardinal Wolsey caused many copies of it to be burned, because it too fully, and perhaps too faithfully, detailed the doings of the clergy.

Robert Recorde ought to be mentioned, not only because he was employed by Kyngston, the printer, to collate and (as we would now call it) edit Fabyan's Chronicle—comparing it with Geoffrey of Monmouth and the other authorities on which the merchant-author had relied—but also, as De Morgan says, he was "a man who deserves a much larger portion of fame than he has met with." He was born in Tenby, Pembrokeshire, entered Oxford in 1525, was chosen fellow of All Souls in 1531. He took his M.D. degree at Cambridge in 1545, and returned to Oxford to teach arithmetic and mathematics.

There "he was honoured of all that knew him for his great knowledge in several arts and sciences." In 1547 he went to London, and was physician to Edward VI. and Mary. He was the earliest original writer on arithmetic in England; the first therein to adopt the Copernican astronomy; and he collected from many sources all that was then known of algebra, of which he was a great improver. He gave us "The Ground of Artes," a treatise on whole numbers and fractions; "The Whetstone of Witte," on the higher arithmetic; "The Pathway to Knowledge," on theoretical and practical geometry; "The Castle of Knowledge," on astronomy, and several professional works on anatomy and physic. He died in the King's Bench, 1558, and was probably buried in St. George's Churchyard, Southwark.

Dr. Thomas Wilson, son of Thomas Wilson of Stroby, Lincolnshire, was educated at Eton and at King's College, Cambridge. He afterwards became tutor to Henry and Charles Brandon, the two sons of the Duke of Suffolk. In 1551 he published "The Rule of Reason, containing the Arte of Logic," in 1553 "The Arte of Rhetoric," and in 1570 a translation of seven of the orations of Demosthenes. On the accession of Mary, Wilson found it expedient to visit the Continent. He took the degree of LL.D. at Ferrara. On visiting Rome he was, "as a presumptuous and dangerous heretic," seized by the Inquisition, imprisoned, and, it is said, tortured. On the demise of Pope Paul IV., 1555, the mob broke open the dungeons of the Inquisition, and Wilson had the good fortune to escape. When Elizabeth's reign began he returned to England, entered the public service, and rose rapidly. He was successively master of the Court of Requests, master of St. Katharine's Hospital, near the Tower, private secretary to the queen, ambassador to the Low Countries and to Scotland, one of the secretaries of state, 1577, and ultimately, in 1579, Dean of Durham, in which office he died, 1581. A small elementary manual on the "The Arte or Crafte of Rhetoryke" had been issued in 1524, 1530, and 1532 by Leonard Cockes or Cox, "for fame spells his name both ways;" and in 1550 Richard Sherry, schoolmaster of Magdalene College at Oxford, published "A Treatise of Schemes and Tropes," gathered out of the best grammarians and orators, which he supplemented by a "Treatise of the Figures of Grammar and Rhetoricke" in 1555; but these were rather school compilations than original productions. Wilson's work is therefore justly regarded as the first regular and systematic exposition of rhetoric, intended directly for the use of those who wished to write in English. He advises his readers "never to affect strange ink-horn terms," nor to "ponder their talk with over-sea language," "English Italianated," nor "Latin their tongues that the simple cannot but wonder at their talk;" and he objects to the use of such Don Armado-like phrases as these:—"Pitiful poverty prayeth for a penny; but puffed presumption pauseth not a point, pampering his paunch with pestilent pleasures, procuring his passport to post it to perdition, there to be punished with pains perpetual." The work is full of excellent recommendations on the art of prose composition, and is of great interest for the light it throws upon the ideas of correct writing entertained in those days when English composition was being made a studied art.

The earliest specimen of literary prose in the Scottish form of writing English, we have in John Bellenden's translation of "The History of Scotland," by Hector Böece (published in 1536, the year of the death of Böece), and five books of Livy's "Annals." Both works were undertaken at the request of James V., and Sir David Lindsay thus directs that king's attention to the use and worth of the former.

"The Cronikles to know I thee exhort,
Quhilk may be mirror to thy majestie;
There sall thou find baith guid and evill report
Of everie prince, efter his qualitie;
Though they be deid, their deeds sall not die,
Trust well, thou sall be stylit in that storie
As thou deserves—put in memorie."

"The Negociacions of Thomas Woolsey," by George Cavendish, one of the few who remained faithful to the great cardinal after his fall, is a valuable contribution to biographical literature, and supplies striking and vivid pictures of the life of England in the early days of Henry VIII. It includes a parallel between Wolsey and Laud. Along with this may be mentioned a poem entitled "The Life and Death of Thomas Wolsey, Cardinal" (1599), by Thomas Storer, a Londoner, a student of Christ Church, Oxford, M.A. 1594; and "had in great renown for his most excellent view of poetry," specimens of which appeared in 1600 in "Belvedere: or the Garden of the Muses," "England's Helicon," and "England's Parnassus." Storer, who died in 1604, has drawn up the history of the great cardinal with elegance and fidelity. The poem is divided into three parts—his aspiring, triumph, and death. It is said to have suggested some passages in Shakspeare's Henry VIII. These lines bear some resemblance to the reflections made by the cardinal on his fall, act iii. scene 2:—

"If once we fall, we fall Colossus-like,
We fall at once like pillars of the sun;
They that between our stride their sails did strike,
Make us sea-marks where they their ships do run,
E'en they that had by us their treasure won."

Storer is not often recognized among our poets, and therefore the following specimen of his power—a description of "Religion"—may not be unacceptable:—

"In chariot framéd of celestial moulde,
And simple purenesse of the purest skie,
A more than heavenly nymph I did beholde,
Who glancing on me with her gracious eie,
So gave me leave her beautie to espie;
For sure no sense such sight can comprehend
Except her beames their faire reflection lende.

Her beautie with Eternitie beganne,
And onlie unto God was ever seene:
When Eden was possessed with sinfull man,
She came to him and gladly would have beene
The long-succeedinge world's eternal queene;
But they refuséd her, (O hainous deede!)
And from that garden banished was their seede.

Since when, at sundrie times in sundrie wayes
Atheisme and blinded ignorance conspire
How to obscure those holy burning rayes,
And quench that zeale of heart-inflaming fire
As makes our soules to heavenly thinges aspire;
But all in vaine! for maugre all their might
She never lost one sparkle of her light.

Pearls may be foiled and gold be turned to drosse,
The sun obscured, the moone be turned to bloode,
The world may sorrow for Astræa's losse,
The heavens be darkened, like a dusky woode,
Waste deserts lie where watery fountains stoode;
But faire *Theologie* (for so shee's hight)
Shall never lose one sparkle of her light.

Sir Thomas Elyot, son of Sir Richard Elyot, the head of a Suffolk family, received a university education—being M.A. and D.C.L.—travelled extensively in Europe, and on his return was introduced to the court of Henry VIII., who employed him on various embassies, and acted as clerk of the king's council. He was grammarian, Grecian, philosopher, physician, and miscellaneous writer. He died in 1546, and was buried in Carleton Church, Cambridge, of which shire he was sheriff. To him we owe "The Governour" (1531), one of the earliest English treatises on education, dealing not only with scholastic training and discipline, but also with the means of improving morals and curbing vice; "The Castle of Health" (1532), containing sound hygienic advice on diet and exercise; a tract on "The Knowledge which maketh a wise Man;" "Pasquyll the Playne," a semi-serious Socratic dialogue between Pasquyll, Gnatho (tongue-clever), and Harpocrates. Pasquyll is represented as an old talking statue in the streets of Rome, Gnatho advocates talkativeness, Harpocrates taciturnity, and the argument is conducted with considerable humour and subtlety, white Pasquyll acts as critic. Neither, as is the case with so many disputants, is convinced, and they leave their censor standing in his place, soliloquizing:—

"Now when these fellowes come to theyre maister they wyl tell al that they have h[e]ard of me; it maketh no matter,

for I have sayd nothyinge but by the way of advertisement, without reprochying of any one person, wherewith no good man hath any cause to take any displeasure. And he that doth by that whyche is spoken, he is soone spied to what parte he leaneth. Judge what men lyst, my thought shall be free."

Other works by Elyot are "The Bankette of Sapiense" (1542), "A Defence or Apologye for Gode Women" (1545), "A Preservative against Death" (1545)—a moral discourse, showing accurate knowledge of the Scriptures and wide acquaintance with the writings of the Fathers. He contributed a number of translations from Greek and Latin, and made "one of the earliest attempts towards the promotion of lexicographical literature," by preparing a Latin-English Dictionary, compiled from the originals, considerably superior to the vocabularies then common, and in fact the foundation of most of the works of a similar nature which have been subsequently undertaken.

Sir Thomas More, born 1480, in Milk Street, London, was son of one of the justices of the King's Bench. He waited at the table of Cardinal Morton, who predicted that he would "prove a marvellous man." He had true genius, a mind enriched with all the learning of his age, and a heart attuned to every virtue. He was educated at Oxford, and had a seat in Parliament when twenty-two. For success in a mission to Flanders, Henry VIII. made him a knight in 1516; and when Wolsey fell, More, the first layman who ever held the office, was appointed Lord Chancellor. Henry was offended at More's reluctance to sanction his marriage with Anne Boleyn. More was a sincere Roman Catholic. Henry claimed from him an oath to maintain the succession resulting from that marriage. He refused. This was reckoned high treason. He was condemned, and going to the scaffold,

"A dauntless soul erect, who smiled on death,"

he was beheaded 6th July, 1535. More wrote a great number of theological treatises, and a history of Edward V. and his brother and Richard III. The materials for this history were supplied by Cardinal Morton and other contemporaries. It is composed in excellent English—the language being pure and well chosen, and the style clear, yet charming, though now its sentences seem archaic. It was first published anonymously in Hardynge's Chronicle, 1543. On this work Shakspeare has mainly depended for the materials of his great epical play.

More's "Utopia," which was written in Latin, was translated by Ralph Robynson, who was a citizen and goldsmith of London, in 1551; but this work, which has provided the languages of Europe with a name suggestive of the ideal perfection of a state, does not, as More produced it, form a part of English literature. It is a politico-philosophical romance, picturing a commonwealth whose supreme laws, social customs, and domestic usages are strictly accordant with good reason, kindly feeling, and mutual toleration.

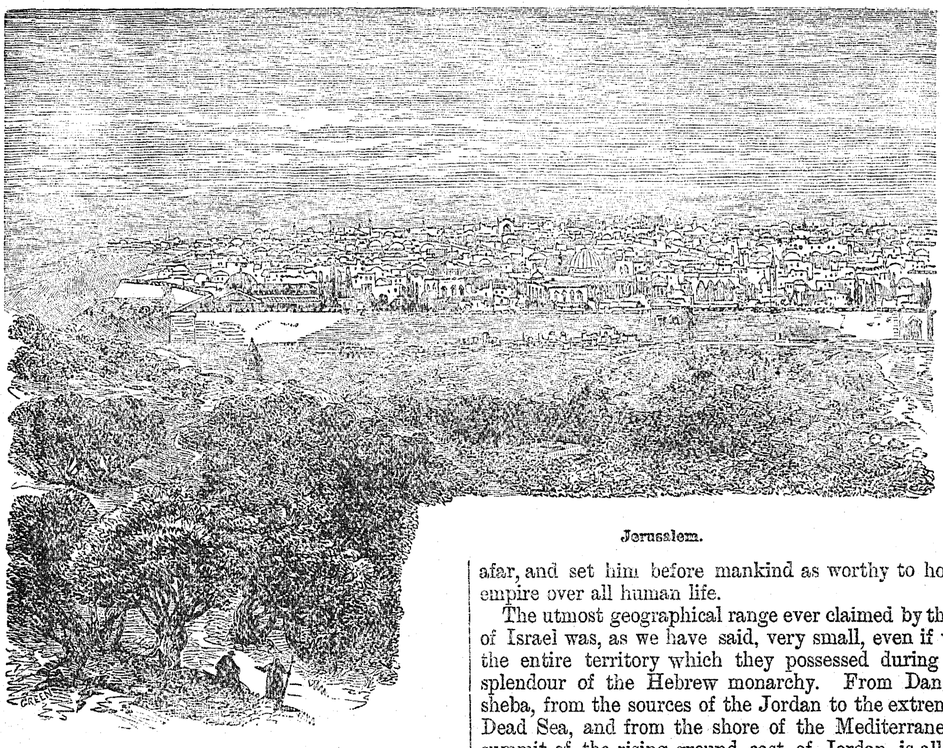
Most general readers know from Milton's sonnet, that Sir John Cheke

"Taught Cambridge and King Edward Greek."

He was considered one of the best and most learned men of his age, a singular ornament to his country, and one of the revivers of polite literature in England. Ascham describes him as "the cunningest master, and one of the worthiest gentlemen, that ever England bred." Nash spoke of him as "the exchequer of eloquence, a man of men [who] supernaturally traded in all tongues." He was born in Cambridge, taught by John Morgan, studied at St. John's College, was made provost of King's College, 1543, appointed tutor to Prince Edward, 1547, knighted 1549, exiled 1553, waylaid in Belgium and taken to the Tower, 1556. There he recanted, and, after great sorrow, died in London, September 1557. He wrote a "Commentary on Psalm cxxxix.," "A Remedy for Sedition" (1536), "The Hurt of Sedition" (1549); but his main work was a translation of the New Testament directly from the Greek, printed in 1550. "A Royal Elegy on King Edward VI." by him was published in 1610. Of his numerous publications and (yet unpublished) MSS., now in the British Museum, this is not the place to say more than that they fully prove his scholarship, patriotism, good sense, and piety.

Roger Ascham is often designated "the father of English prose," and though Mandeville's Travels, Malory's "Mort d'Arthure," Berner's Froissart, and More's historic work show good writing, it must be admitted that Ascham first consciously and advisedly set himself "to speak as the common people do, to think as wise men do, as, so should every man understand him and the judgment of wise men allow him." Fuller says, "His 'Toxophilus' is accounted a good book for *young* men, his 'Schoolmaster' for *old* men, and his 'Epistles' for *all* men." In the first-named, "he designed," Dr. Johnson remarks, "not only to teach the art of shooting, but to give an example of diction more natural and more purely English than was used by the common writers of that age." "He was," as *The Retrospective Review* puts it, "one of the first founders of a true English style in prose composition, and one of the most respectable and useful of our [early] scholars;" and Queen Elizabeth, who did not put a slight value either on money or learning, declared that "she would rather have lost £10,000 than her tutor Ascham." He was born at Kirby-Wiske, near Allerton, Yorkshire, about 1515, was educated at St. John's, Cambridge, and was made fellow of his college when eighteen. He succeeded Sir John Cheke as public orator, and was Latin secretary to Edward VI. The Princess Elizabeth, in 1548, was put under his tutelage. In 1550 he travelled as secretary to Sir Richard Morysine, ambassador to the court of Charles V. He resigned his fellowship and married Miss Margaret Howe in 1554. His "Toxophilus"—a dialogue between *Philologus*, "lover of learning," and *Toxophilus*, "lover of archery," concerning the respective attractions of book and bow, the scene of which is set among the wheat-fields of Cambridge—was issued in 1545; and his "Schoolmaster"—which was written at the suggestion of Sir Richard Sackville, of Buckhurst—in 1571. This work is in two books: the first sets forth two stages of Ascham's *interlineary* method of learning Latin, and urges that "love is fitter than fear, gentleness better than beating, to bring up a child rightly in learning." Having distinguished between "quick wits" and "hard wits" and discussed "Plato's seven plain notes to choose a good wit in a child," the author castigated the "Italianated" Englishman of his age. In the second book he describes the remaining stages of his method, criticises Latin authors, and gives incidental notices of some English writers. This book is still valuable for the rules and principles of teaching it expounds. The three special points he desired to inculcate as essential to a sound education were—truth in religion, honesty of living, and right order in learning. Plato's seven points, which he explains, are—(1) aptness of wit and will, (2) goodness of memory, (3) love of learning, (4) eagerness to progress and care in doing so, (5) readiness of reception, (6) inquiringness of disposition, and (7) hearty love of honest praise. He maintains "that if ever the nature of man be given at any time more than other to receive goodness, it is in innocency of young years, before that experience of evil have taken root in him. For the pure clean wit of a sweet young babe is like the newest wax, most able to receive the best and fairest printing; and like a new bright silver dish never occupied, to receive and keep clean any good thing that is put into it." "Learning," he says, "teacheth more in one year than experience in twenty; and learning teacheth safely, when experience maketh more miserable than wise. He hazardeth sore that waxeth wise by experience. An unhappy master [mariner] is he that is made cunning by many shipwrecks; a miserable merchant, that is neither rich nor wise but after some bankrouts (*i.e.* bankruptcies). It is costly wisdom that is taught by experience."

Ascham's "Schoolmaster" was published by his widow shortly after his death. This event took place 30th December, 1568, while he was overtaxing himself to produce a Latin poem to be presented to the queen on New-Year's Day, 1569. He was buried in St. Sepulchre's Church. Dr. Alex. Nowell, dean of St. Paul's, preached his funeral sermon, and George Buchanan composed an epigrammatic epitaph, expressive of high admiration of the character, talents, and goodness of this acute, learned, and laborious scholar, tutor, and author.



Jerusalem.

HISTORY.—CHAPTER VIII.

JERUSALEM—KINGS OF JUDAH AND ISRAEL—THE CAPTIVITY—ROMAN SYRIA—THE PTOLEMIES AND THE SELEUCIDS—THE HERODIAN DOMINIONS—THE DESTRUCTION OF JERUSALEM.

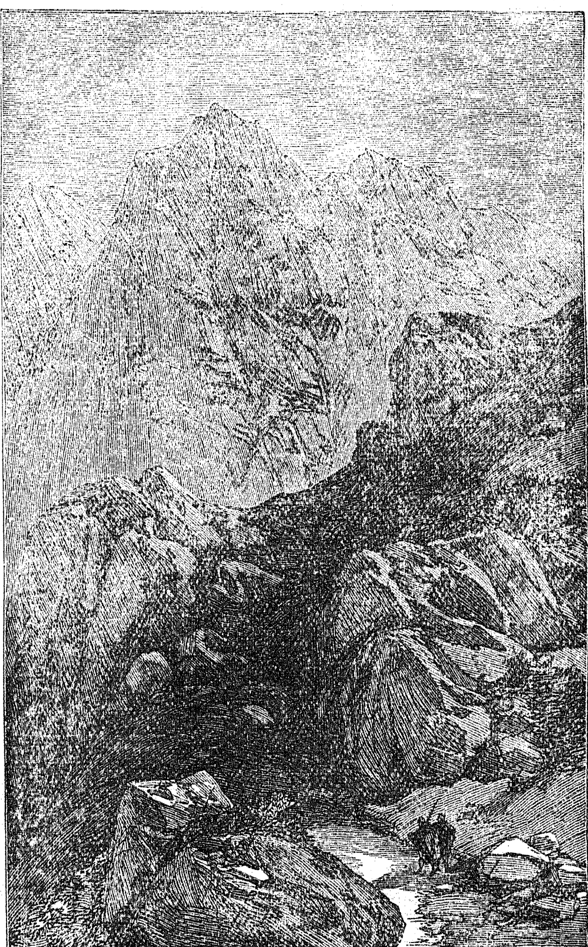
PALESTINE is an oblong territory lying between Lebanon and Sinai. Two sets of highlands descending from Syria extend through the entire length of the land, having the separating Jordan flowing between them. The Land of Canaan consists mainly of rugged hills and narrow valleys, but the plains of Esdraelon and Sharon are found in the west and the plain of Hauran in the east. Its northern and central districts are fertile, but in the south, near the Dead Sea, it is rocky and sterile. The geographical position of Palestine is unique. It is scarcely more than a coast strip in the centre of the border of the three continents of antiquity—linking, as it were, Europe and Africa to Asia; while the Great Sea to the west gave it a highway to all nations. Here, in the early periods of the world's annals—while mythologic legend and fantastic fable form the only available materials for the history of other lands—the soil was trodden by patriarch, priest, and prophet, the throne was filled by mighty kings. and the worship of God prevailed. The heroisms of the earlier judgeships of Gideon, Jephthah, and Samson were achieved long before the Persian hosts under Xerxes perished before the valour of the Greeks at Marathon and Salamis. The marvellous shepherd boy of Bethlehem, who wielded with equal skill the crook, the sword, the sceptre, and the lyre, and the sage Solomon, his son, whose magnificence and wisdom were the world's wonder, carried their rule northwards towards the Euphrates and southwards to the Red Sea. The Philistines on the west, the Moabites and Ammonites on the east, the Arab nomads and the Edomites of the south, and the Syrian states of the north were tributary to them and under their sway. The land they ruled was small in extent, but the influences which have gone forth from it have been mightier in their effects on civilization than those that have proceeded from any other equal extent of territory. Alike by Arab and Jew, Mussulman and Christian, are the historic incidents of sacred writ accepted. Here, in the fulness of time, Messiah came, and here the foundations of that spiritual sovereignty over Mansoul were laid, which has spread the law and love of Christ afar, and set him before mankind as worthy to hold Divine empire over all human life.

The utmost geographical range ever claimed by the children of Israel was, as we have said, very small, even if we reckon the entire territory which they possessed during the brief splendour of the Hebrew monarchy. From Dan to Beersheba, from the sources of the Jordan to the extremity of the Dead Sea, and from the shore of the Mediterranean to the summit of the rising-ground east of Jordan, is all the space the Jews ever possessed. Two degrees of latitude, and two degrees of longitude, more than include the whole of their territory; and within this limited space there were districts which, if they did not retain their independence, were only tributaries, and never mixed or became amalgamated with the Hebrew people. Thus Idumea was a dependency of Israel during the reigns of David and Solomon; so was Damascus, and beyond it Tadmor in the desert. The peninsula of Sinai belongs to Jewish history as the scene of their forty years' educative wandering, and of the giving of the law. The declivity of Mount Taurus beyond the Euphrates, is historically connected with Hebrew life as the birthplace of their father Abraham. But all these districts—Idumea, Southern and Northern Syria, Western Mesopotamia, &c., had only a transient connection with the promised land of Judea. We have a dim glimpse of countries beyond the Euphrates, as those whence the Assyrian hordes thronged into Judea—of the territory "beyond the river of Egypt," as the place whence the Egyptians and the Egyptian invasions came, and where the days of Hebrew bondage were endured—of the ocean and its isles, or the region from which the Grecian Empire came in the rush of its might; but of all these wide domains the old Hebrew geographers knew nothing distinctively. The region of Judea is graphically and distinctly portrayed, while all the regions beyond Jordan—the Syria of Damascus, Tadmor in the desert, Idumea and Arabia, are faintly and dimly seen in the background. This is the remarkable peculiarity of Hebrew geography—its precision within a narrow circle, and its growing indistinctness until the eye reaches the verge beyond which all is conjecture, and nothing can be seen. This would, independently of any external evidence, prove it to be native to that land—a territory within which it had been accumulated or stored up, not so much by experience as by inspiration. Nowhere but in the lands around Jerusalem could such knowledge of remote territories and such ideas of the distinguishing features of nations and policy have been then gained; for only there were influences aggregated which were calculated to secure the national growth of a peculiar people, whose experiences should ripen into character, and whose civil and religious politics should be such as to preserve property against selfish accumulations and conserve national prosperity while maintaining personal and family interests

and independence, at the same time that the conscience should be at once controlled and trained by power, faith, and hope.

The information we have respecting the Hebrew nation is derived almost exclusively from the Scriptures of the Old Testament. These writings are either historical, prophetical, or poetical. The first—in order to ascertain the events of Jewish history, the growth and vicissitudes of the state—must form the groundwork of our investigations. The other two classes of writings must be used as supplementary and illustrative, as incidentally corroborating statements made, or supplying notices of facts omitted; as furnishing intimations of the modes of thought and feeling among the people, in a more explicit manner than a mere historical narrative could convey; and as affording the best tests of the progress made by them in knowledge and civilization.

The Hebrew volume comprises (1) The Pentateuch or five books of Moses, containing much narrative, an exposition of the law, and many episodes of interest as well as splendid reliques of ancient poetry; (2) twelve books professedly or mainly historical, beginning with Joshua and ending with Esther, partly in the form of annals or chronicle registrations of events, and partly biographical, but almost always investing each picture or event with moral elements and attributes; (3) five poetical books, including Job, Psalms, Proverbs, Ecclesiastes, and the Song of Solomon, in which many historical allusions occur, and from which many historical inferences may be drawn; and (4) seventeen prophetical books—five greater and twelve minor, partly poetical and partly in prose; these latter, of course, supply many historic incidents and make reference to many events in the lives of men and the annals of nations of much interest to the student. The narrative portion of the Pentateuch contains (1) an account of the creation of the universe and of man, the introduction of sin and the prevalence of idolatry, the evil consequences of the iniquity of the early inhabitants of the earth, and the deluge in which the Divine displeasure was manifested; (2) the repeopling of the world, the dispersion of men through its various territories, beginning in the East. Then gradually confining the scope of the record, it (3) brings out the origin of a chosen people to whom was confided the task of bearing witness for Divine law in the promised land. The idea of this resolve is given in Eccles. xvii. 17, "In the division of the earth God set a ruler over every people, but Israel is the Lord's portion." Faithful to Him, they would be free and happy; faithless, they would be conquered, enslaved, and exiled. This elect branch of the Semitic family migrated from Mesopotamia into Palestine, and either acquired or took the distinctive name of Hebrews (*Ibri*, from the other side) from Abraham or from Eber, the great-grandson of Shem, from whom Abraham was descended. After detailing the events of the lives of the Chaldean patriarch, and of Isaac and Ishmael, Jacob and Esau, of Joseph and his brethren, it relates the incidents which led to the going down into Egypt, when the hardy herdsmen of Canaan became a horde of slaves suffering a long and hard bondage under the Pharaohs; of their deliverance thence, of their education in the wilderness into nationality of spirit and character, and of their training under the legislator Moses in law abidingness and community of interests, feelings, and aspirations. After hours of dreadful terror, followed by the joy of a marvellous deliverance, they "sang a song to the Lord." In the deserts around Horeb and Sinai they listened to the Eternal voice, and the process of Divine education was begun. Moses, under all-wise guidance, taught them to march tribe by tribe, and family by family, and to encamp in the same manner. He appointed seventy-two judges, six for each tribe, to decide questions between man and man, with the right of appeal to himself; he taught them a ceremonious ritual and a moral system of worship; he appointed the services of the altar, and he insisted upon the unswerving worship of the one only God, Jehovah. Thus, for forty years, did he labour to train his people to habits that would enable them to conquer a country, and to retain it and enjoy it as a home. He strove, by imparting wisdom, purity, and humility, to make them capable of greatness and freedom. The Books of Joshua, Judges, and Ruth relate the chief circumstances of Jewish history, from the invasion of Canaan under Joshua to the commencement of the monarchy under Saul. This period was occupied by the Hebrews, partly in conquering and partly in defending themselves from the vengeance of those enemies whose territories they had invaded. The entire extirpation of the idolatrous tribes of Canaan, and the complete possession of Palestine by the seed of Abraham, formed the groundwork, the substance, and the theory of their future government under Mosaical ordinances. The children of Israel arrested the accomplishment of the object contemplated. Two and a half of the tribes fought in a half-hearted manner only; and the rest, when they had conquered enough for their immediate purposes, regardless of the wants of futurity, yielded themselves to



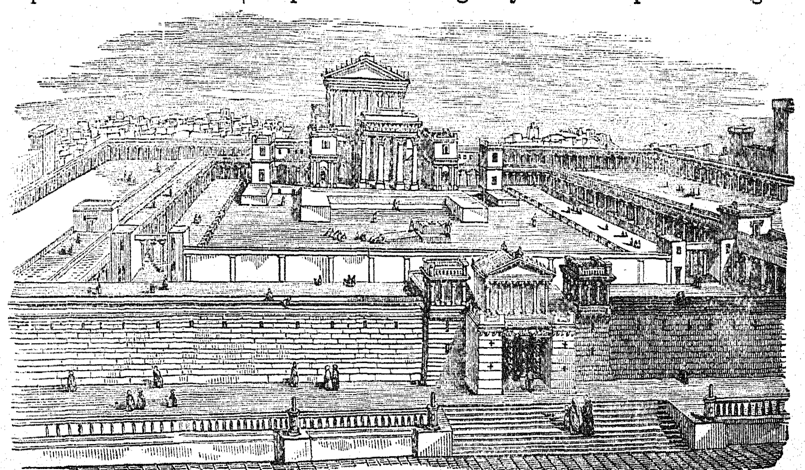
Defiles of Mount Sinai.

slothful inaction. The original inhabitants, left in their hilly fastnesses, still retained sufficient strength to sally down upon their invaders, and to avenge at times their wrongs. Kept in terror by these hostile demonstrations, the tribes were deterred from dispersing themselves and taking possession of their allotted portions. Dan dwelt for a time in the borders of Simeon; and when their numbers increased, so as to require ampler possessions, they felt themselves compelled to attack the weaker districts, leaving sometimes a stronger power between their detached encampments; and often, as in the case of Dan, a whole tribe was tempted to forsake the worship of God for that of idols, and to conform to the ways and customs of the tribes in their vicinity. The very ideal of a life of peaceful happiness should have been theirs. The land in which they dwelt was beautiful and fertile.

"flowing with milk and honey," and so divided that each could sit under his own vine and fig-tree. The air was serene, the seasons finely varied, the soil not too difficult of tillage, and affording choice pasturage almost everywhere. Each week of work was closed with a Sabbath's rest, and every period of the year had its appropriate festival. The Passover preserved the memory of the Exodus; Pentecost called them to thanksgivings for the ripened harvests of the year, while it recalled the memory and the laws of Sinai; at the Feast of the Tabernacles they dwelt in booths to remind them of their wilderness wanderings. They were separated from the idolatrous people of the old world, and their worship was like the casket in which the holy jewel of truth was enshrined, that it and they might be kept unscathed by the sin which surrounded them. But this they made a cause of isolation of heart, and separate interests began to swell in the spirits of different tribes. Stubbornness, passionateness, and fanaticism grew upon them, and dissolute habits prevailed. The lessons taught in the Sinaitic and ceremonial law were forgotten. Instead of being submissive to Jehovah, under covenant sanctions, they adhered to earthly rulers and trusted in war-like champions and popular chieftains. They frequently sinned, and were often humbled. They sought supremacy by mere human policy, and they failed. Thus the unity of the nation was broken up, and scattered and weakened, it became powerless and inert; instead of rejoicing in God as their lawgiver, judge, and king, who made their sanctuary His dwelling-place, "they became vain in their imaginations and their foolish hearts were darkened." Their faith became dimmed instead of being active and operative. It was confidence which should have inspired the utmost daring and achieved the most signal victories. But when this, the Pole-star by which they were to steer, became obscured, hope fled and disaster and slavery ensued. "There was no king in Israel in those days, and every man did that which was right in his own eyes." Though judges were recognized, the law had lost its power; so that in all respects the state of the Israelites, from the death of Joshua till Samuel, may be regarded as retrograding and degraded. Yet, in the institutions and doctrines of their lawgiver, they did possess what, if rightly used, might have kindled them to nobler life. There was always, even in the worst of times, a spirit of union kept up among the tribes. Midway between Jerusalem and Mount Tabor was the site of the tabernacle, Shiloh. It formed a central point where the union of the tribes could be maintained. The seventy-two upon whom the spirit of prophecy came in the days of Moses, had never been without successors. To the institution of judicial magistrates God added that of a serving priesthood.

With ordinary exertions, and the occasional victories of impassioned leaders, the Israelites learned how to maintain the conquest they had won; but this was not enough. They wished themselves consolidated as a state, under regal sway; they coveted a mortal monarch to rule in peace, and lead in battle—a spirit for which Samuel severely chid them, yet at last he yielded to their will, by anointing Saul king of Israel. In the Books of Samuel and Kings, we find the history of the monarchy to its close at the Captivity. In the Books of Chronicles we find the same history presented in a more condensed form. The chief events related in those twofold exhibitions of the history of the Hebrew race run thus:—Saul, for his interfering with the priestly office, by offering a sacrifice with his own hands in the absence of Samuel, is denounced by that prophet, who afterwards anoints the shepherd boy David, the son of Jesse, who, on the death of Saul on Mount Gilboa, ascended the throne.

The shepherd lad, who had grown up among battles and lived through persecutions, and who yearned for the return of such days as his great-grandfather Boaz spent among his reapers, saw Saul decline in piety, popularity, and power, and the times became rugged and perilous. When he was anointed successor to the living but degenerate Saul, he brought a better spirit to the throne. The youthful gallantry which despised the pride of the Philistine, and laid the haughty Goliath prostrate in the dust; the nobleness of soul which led him to spare Saul when, asleep in a cave in the wilderness of Engedi, the monarch's life was in the hand of his son-in-law; the ability he possessed in the wielding of the sword, the handling of the harp, the using of the pen—graces of character and gifts of genius rare in any land, and quite unexpected in Israel; the errors, temptations, sins, and sorrows of the minstrel-monarch, impart interest to David's history. We see with delight his efforts to rouse the Jewish people to a sense of privilege and to the triumphal grandeur of their God-protected state. He extended their territories, remodelled their institutions, inspirited their faith, and longed to see Jehovah vouchsafe to be the chief shepherd of the flock he led in Palestine. He transferred the government from Hebron to Jerusalem, which he had taken from the Jebusites, and, at the instigation of the prophet Nathan, made preparations for the erection of "the house of the Lord." But the contagion of the degraded despotisms of surrounding lands infected sovereign and subject; dark days came, enemies arose, wars were waged, and trust in chariots and horses and an arm of flesh prevailed. Worse than all, unworthy passions and ungodly deeds dimmed the lustre of the life of the psalmist, the man, and the monarch. He dared not build the Temple, for he was a man of blood. A hopeful moment of expectation gilds his latter days with glory, when he and his people provide with noble self-denial the materials for the building of that house of God in which he was never to lift up his voice in prayer, yet in which his kinsmen after the flesh were to sing, as the songs of Zion, the psalms of their singularly selected shepherd-sovereign.



Solomon's Temple.

Solomon his son beautified the holy city, and erected the splendid Temple, to which the tabernacle was removed from Shiloh. He was the hereditary monarch of a peculiar people, and there was "bestowed upon him such royal majesty as had not been on any king before him in Israel." To him, not only "riches, and wealth, and honour," such as no other king had had, but also "wisdom and knowledge" were granted. Yet the worship established on Moriah's Mount, with all its spiritual fitness for the government of the heart, did not so enter into his own life and that of his people as to restrain them from following evil courses. He gloried in the splendour of the Temple as a gain to his magnificence. He fortified Jerusalem that he might intrench himself therein, and the palace he reared was for his own comfort and renown. In the pursuit of material prosperity, in his love of lavish luxury, in his endeavours to extend his dominion beyond the promised bounds, Solomon endangered the independence, the comfort,

and the faith of his subjects, and darkened within himself the spirit of submission to the behests of Him in whom alone dwelt the authority and majesty of which his power and sovereignty were only the earthly symbols. Fascinated by female flatteries he fell from the lofty religiousness of soul in which he had been trained into very low depths of ritualistic idolatries; personal sin involved him in political blunders as well as religious offences. The unity of the nation, on which its strength depended, lacking unity of faith, was destroyed. The jealousies and separatism of the tribes were re-excited, and just when his land pressingly required special control, the king, grown prematurely old, was so changed in heart that he was unable to repress sedition within or repel disaster without the kingdom. The bright lyrist of the Song of Songs, the prudent proverbialist, the monarch-preacher was too effeminate to wield the sceptre with a strong hand at home or the sword with sharp decision abroad. The prophet's fire was kindled against his government, and Ahijah the Shilonite foretold the disruption of his kingdom, and the fall of the mighty monarchy to which he had succeeded. It is true that David's last-born son, and Nathan's favourite pupil, greatly enhanced the external glory of Palestine among the monarchies of antiquity. Solomon completed the subjection of the tribes intermingled with the Israelites—augmented his kingdom—formed alliances with the Tyrians—and made with them conjoint mercantile speculations to the Red Sea. He formed matrimonial alliances with the neighbouring powers, and caught from the daughter of Pharaoh, king of Egypt, in all likelihood, the vanity of rivalling the splendour of her ancestors.

But with all this getting of outward glory there was a sad forgetting both by prince and people of the high faith and holy practice, of the inner glory of righteousness and peace, which they had been taught. Hence the splendid reign of Solomon, like most other splendid reigns, was more gratifying to the monarch's vanity than useful to his people's progress. This we infer from the pathetic complaint made to his son Rehoboam on his accession to the throne:—"Thy father made our yoke grievous; now, therefore, make thou the grievous service of thy father, and his heavy yoke which he put upon us, lighter, and we will serve thee." The tyrannical answer which the young monarch gave led to the rending of the kingdom. Of the twelve tribes—hitherto joined together by faith and ritual, by tradition and law, but of late only feebly and loosely aggregated as parts of a great whole—ten revolted and formed themselves into the kingdom of Israel, and with the elevation of Jeroboam to the sovereignty of these northern tribes, the establishment of a new dynasty over the ten tribes was accomplished. Judah and Benjamin, remaining faithful to the house of David, took up arms to reinforce the power of Rehoboam over Israel; but the disseverance was made complete, and disunion and impiety combined to bring on the Jews the dark doom of conquest and captivity. The temporal power of the Israelites was broken. One after another the external dependencies asserted their independence. Israel and Judah wasted their energies in war against each other, and ultimately fell an easy prey to their proud neighbours from the east.

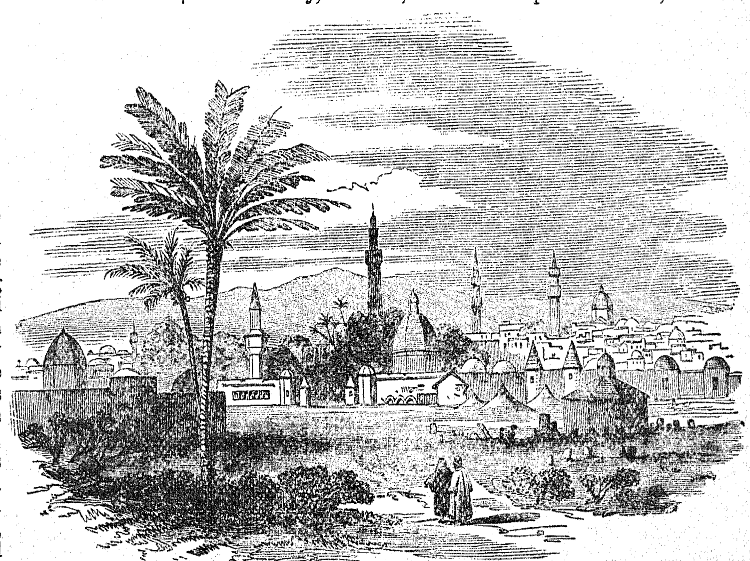
The sequel of the history of the Hebrews is of a very mixed nature. That of the kingdom of Israel discloses a long roll of wicked kings, and very few indeed in Judah were eminent for piety. Jeroboam was forceless in character, and sought rather to secure his personal power than to found a dynasty. The army made itself the dictator both over king and subjects, and Amos prophesied the destruction of his house by the sword. Jeroboam was defeated by Abijah, and Baasha slew Nadab, his son and successor, at Gibbethon. Asa and Benhadad of Damascus defeated this soldier-king, whose son Elah was slain, while suffering from a debauch, by Zimri. He, after a seven days' reign, was reduced by Omri to retreat to the palace in Tirzah, and, setting that on fire, died in the flames. Half the people desired to raise Tibni to the throne; Omri upheld the validity of the army's nomination. After a civil war of four years' duration Omri ruled at Tirzah, then removed to Samaria, and in a vigorous but unscrupulous manner not only held sway himself, but handed the sceptre to his son. Ahab married Jezebel of Tyre, repulsed Benhadad II. from Samaria, and next year at Aphek defeated him; but was himself slain by "a certain man who drew a bow at a venture" at Ramoth-Gilead, in accordance with a prophecy that, for his treatment of Naboth, his house should be entirely destroyed. Ahaziah, who had been trained in idolatry, was rebuked for his impiety by Elijah, and not only in him, but in Jehoram, Micaiah's prophecy was fulfilled and Omri's dynasty expired. Jehu began his reign by extirpating the seed of Ahab, his courtiers, and the priesthood of Astarte; and swooped down by massacre, in the temple at Samaria, the whole heathen population of Israel. Hazael, the ablest of the Damascene sovereigns, triumphed over Jehu's son Jehoahaz, made him a tributary vassal, and lorded it haughtily over the Hebrews. His son and successor Joash overcame the Syrian sovereigns, defeated Benhadad thrice, was victorious at Bethshemesh over Amaziah, and handed down the sceptre to his son Jeroboam II., who not only repelled the Syrian invaders and took Damascus, their capital, but also re-extended his kingdom from Hamoth to the Dead Sea. Zechariah, after a six months' reign, was slain by Shallum, who in a month was overthrown by Menahem, whose ferocious and ungodly reign lasted for ten years, during which time the Assyrians first appeared as a hostile force on the frontiers of Israel, but were bought off by a gift of a thousand talents. Pekahiah, who succeeded his father Menahem, after a brief reign of two years, was treacherously murdered by Pekah, his captain, who seized the sceptre and refused to yield tribute to Assyria. For this purpose he allied himself to Rezin of Damascus, and planned with him the spoliation of Judah. They went up against Jerusalem to war against it. They slew in Judah 120,000, and carried away captive of their brethren 200,000, and took away much spoil. By the heroic intervention of Oded, however—who went out before the host that came to Samaria rejoicing in their victory and rebuked them—these captives were released, kindly treated, and restored to their homes. Meanwhile Ahaz had sent unto the kings of Assyria for troops to help him. Rezin was slain, Pekah vanquished, half his kingdom was taken from him, and a larger tribute than ever was enforced. Taking occasion, either from his weakness or his tyranny, Hoshea, the son of Elah, conspired against Pekahiah, slew him, and reigned in his stead. Shalmanezer, when Hoshea had been but three years king, invaded Israel and recompelled its submission. Hoshea entered into a secret alliance with So, king of Egypt, against Assyria. Certain of his own subjects revealed this to the Ninevitic court; their king was seized as a rebellious vassal, committed to prison, and treated with cruelty and indignity. Of his after fate we have no trace. By the Assyrians the Israelites were carried away into captivity, and their lands were colonized by other subjects of Assyria, in accordance with a policy of transplantation common in the East. Dispersed and oppressed, wasted in numbers, shaken in faith, and far from their traditionary temple worship, the Hebrews seemed in part to have lost the charge committed unto them, and only faint memories of the prophecies of a future of restoration inspired them with a hope which somewhat softened their despair.

The division of the kingdom was also the origin of a great religious change. Jeroboam, in order to deprive Jerusalem of its importance as the centre of national worship, erected an altar on Mount Gerizim. The Levites, however, clung to each other and to Jerusalem. Jeroboam was obliged to go further than he had originally intended, and to create a new order of priesthood and a new worship. This thwarted his own purposes. The staid and pious people of Israel continued still to regard the temple at Jerusalem as the centre of the national religion; but the spirit waxed faint where no genuine altar smoked to heaven, and when the Divine ritual was divested of the sanction of the local government. There were colleges or "schools of the prophets," however, in Israel as well as in Judah, who clung faithfully to the holy worship of their fathers. Indeed, the most distinguished of the Hebrew prophets belonged to Israel, and not to Judah. Jerusalem had for these prophets a more than mystic meaning; and, as the two kingdoms fell more and more in worldly prosperity, and their monarchs sank deeper in profligacy, this faith—this habit of seeing in what had

been deemed promises of temporal prosperity a mystic meaning—increased, and kindled in their breasts a higher and a holier enthusiasm. As the kingdoms approached their fall, the enthusiasm of the prophet touched his rapt soul, as it were, with coals of living fire from the altar, and his warning voice was heard in undaunted and unquailing tones above the noise of hosts gathering together for fight, and even engaged in war.

The kingdom of Judah, whose history, of course, ran parallel with that just narrated, possessed many advantages, moral and secular. Though it had a soil less fertile, it had a frontier less exposed to enemies. The northern kingdom had a hardier and more united people; had an organized worship and a powerful hierarchy; an army more distinctly subordinate to the crown; and their administration was less exposed to revolutionary conspiracies. Hence her national existence was extended beyond that of the more populous and powerful revolted state. The three first kings, Rehoboam, Abijah, and Asa, in the hope of re-establishing their authority over the secessionists, carried on an almost incessant war. Though Rehoboam collected an army of 180,000 men, he was forbidden by Shemaiah to use them against his brethren. He fortified the chief towns against siege, and garrisoned them. Shishak brought against him a mighty Egyptian and African host, and he bought a disgraceful peace with the chief treasures of the Temple. Abijah walked in all the sins of his father, and made strong efforts to subdue Israel. He was successful in battle, and by the capture of many cities acquired a temporary increase of his dominions. Asa enlarged his territories and fortified his frontier. Zerah, the Ethiopian invader, was driven with immense loss from Mareshah beyond Gerar; and Asa, by the help of Benhadad of Damascus, compelled Baasha to dismantle the fortresses of Ramah. Hanani remonstrated with him for his readiness to trust in alliances with princes, and forsaking his faith in God. When Jehoshaphat, his son, reigned in his stead, he took a new line of policy, and made a league and entered into a matrimonial alliance with the northern kingdom, his son Jehoram taking to wife Athaliah, daughter of Ahab and Jezebel. He repulsed invasion, and with an active spirit pushed on the prosperity of Southern Palestine. His warlike energy was constantly awake. In his later years he reposed great trust in his son Jehoram, but he seems to have been unworthy of this confidence. After his father's death he put his six brothers and many of his nobles to death. His reign was full of calamities. The Edomites, whom his father vanquished, regained their independence; Libnah rebelled against his government; Philistines and Arabians stormed his palace, slew his wives and all his children, except Ahaziah, plundered his treasuries, and carried many of his people into captivity.

Ahaziah (Jehoahaz) favoured idolatry, and was an ally of his uncle Jehoram, king of Israel. They united their efforts against Hazael, but were defeated at Ramoth-Gilead. Jehu's revolt, which Elisha favoured, broke out while he was visiting Jehoram at Jezreel. They went out to meet Jehu. He shot Jehoram dead, and Ahaziah, being pursued, was mortally wounded, and died at Megiddo. Athaliah, the king's mother, immediately put all Ahaziah's children to death except Joash, who was rescued and secreted by his aunt Jehosheba, and seized the government and ruled for six years. Then Jehoiada the priest produced the infant king. Glad to be freed from the cruelty and idolatry of Athaliah, the people doomed her to death, and placed Joash on the throne of his ancestors. During the life and regency of Jehoiada the nation prospered, but on his death the king was surrounded by evil counsellors, and was induced to revive idolatry. Rebuked by Zechariah, son of Jehoiada, Joash caused him to be stoned to death. Almost immediately afterwards Hazael came from Syria against Jerusalem, and carried off much spoil. While Joash was lying wounded in the fortress of Millo, he was murdered by two of his servants. Amaziah, his son, at once punished the murderers. He made war on the Edomites, and succeeding, took their capital, Petra. He challenged Joash, king of Israel, to battle, and Judah was discomfited. Amaziah was overcome, Jerusalem was surrendered, and he was imprisoned in his own capital. At Lachish he was murdered by conspirators, and Uzziah, his son, who became a wise, pious, and energetic ruler, was called to occupy the throne. He carried his arms victoriously as far as the Gulf of Akaba, and waged victorious war against the Mehunim and Gurbaal Arabs. Gath, Jabneh, and Ashdod, cities of the Philistines, had their walls levelled to the ground by him. He founded new fortified cities in the territories of his enemies, and rebuilt Jerusalem's walls. But, elated with success, he wished himself to conduct the worship of God, and would have burnt incense on the altar. Azariah and other priests opposed this; he persisted, and was smitten with a leprosy, of which he subsequently died. Jotham, who during his father's illness had held the regency, succeeded to the throne. His reign was prosperous. He fought against the King of the Ammonites, and prevailed, making them tributaries for three years. He "became mighty because he prepared his ways before the Lord his God." At the time of the accession of his son Ahaz, Rezin and Pekah were in league against Judah. Isaiah encouraged and advised Ahaz, and, probably, through his counsels their attack on Jerusalem failed. They, however, took the seaport of Elath, and the



Damascus.

Philistines invaded his territories in the south and west. Ahaz sought aid from Tiglath-pileser, king of Assyria, who overran Syria, took Damascus, killed Rezin, and seized the possessions of Israel on the east of the Jordan and in the north. Ahaz was made to appear before Damascus as a vassal of the Assyrian monarch, and compelled to pay for his help with the chief treasures of God's temple and his palace. He fell into idolatry, sacrificed to the gods of Syria, and put faith in necromancy and witchcraft. Hezekiah did not share in the apostasy of his father. He restored the Temple worship, and because it had become an object of adoration, destroyed the brazen serpent used, it was said, by Moses in the healing of the Israelites. On the fall of Israel he invited the surviving remnant of Ephraim and Manasseh to a united Passover. He regained from the Philistines the cities they had won from his father, and overcame their chief places, leaving Gaza and Gath alone in their possession. Waxing stronger in courage, he refused to pay tribute to Assyria. War was threatened, and he, despairing, turned his face to the wall and wept sore. He was reassured

by Isaiah, and by an embassy from Babylon making overtures of alliance. In the joy and pride of his heart he made ostentatious festivals, and paraded the magnificence of his treasures. The cupidity of Babylon was excited. Twice the Assyrian sovereign Sennacherib invaded his land. Peace was granted for a fine of 800 talents of silver, but Sennacherib dealt treacherously with Hezekiah, and sent an army to besiege Jerusalem. Summoned to surrender, Hezekiah prayed, and 185,000 of the invading army in one night "melted like snow in the glance of the Lord." Under his son and successor, Manasseh, the peace and glory gained by Hezekiah were soon lost. He restored idolatry. The Assyrian army, in revenge for the support given to Merodach-Baladan of Babylon, overran Judah, took Jerusalem, and carried the king as a captive into Babylon. Here he repented, and on attaining his freedom and sovereignty he put captains of war in all the fenced cities of Judah, made a league with Psammeticus, and strengthened himself thus against Assyrian aggression. Amon, his son, whose name indicates Manasseh's Egyptian alliance, favoured the idolatry of his allies, and was slain by conspirators, who placed his son Josiah on the throne. Under due guardianship, Josiah improved the manners of the state, and issued a special commission for the restoration of the Temple. Hilkiah, during this work, found the book of the Law, and read it to the king and the people. His zeal for true religion was thereby quickened, and as he was grieved by Huldah's prophecy that his land would be made a desolation and a curse, he endeavoured to avert its fulfilment. When Pharaoh-Necho resolved to carry war into Assyria, and sought to pass from Egypt to Carchemish, Josiah, in a spirit of loyalty to treaties entered into before his time, opposed the march of the Egyptian army. Battle was joined in the plain of Esdraelon, and Josiah being mortally wounded died before he could reach Jerusalem. Jehoahaz (Shallum) was chosen to succeed him, but he had only occupied the throne three months when Pharaoh-Necho, returning from Carchemish flushed with victory, sent a force to depose him and bring him to Riblah. There he was laden with chains, and having been taken to Egypt, died in captivity. Jehoiakim (Eliakim) was by Pharaoh-Necho set on the throne. Nebuchadnezzar, looking on Judah as one of the tributary kingdoms of Egypt, entered Palestine, found Jehoiakim defenceless, besieged Jerusalem, and carried off the king in fetters to Babylon, taking with him also the spoil of the land and the Temple. Jehoiakim accepted the position of vassal-king, and Nebuchadnezzar reinstated him. Three years afterwards, however, he renounced his allegiance, and his overlord sent bands of Chaldeans, Syrians, Moabites, and Ammonites—all now subject to Babylonian sway—to harass the land. He met a violent end, and was buried without ceremony or funeral dirge. In the reign of Jehoiachin, his son, Nebuchadnezzar sent a regular army against Judah; the king surrendered at discretion, and he, his nobles, his retinue, and his household were carried to Babylon, where for thirty-six years he eat the bread of a captive. When Evil-Merodach ascended the royal seat of Babylon, he had compassion on the long-imprisoned king, and gave him a place at his own table. In the meanwhile the last king of Judah, whose own name was Mattaniah, under the titular name of Zedekiah, taken by order of Nebuchadnezzar, was placed in the vassal-throne at Jerusalem, with a sadly impoverished country to govern. He rebelled against Nebuchadnezzar. He and his people mocked and despised the warnings of Jeremiah and Ezekiel, and the King of the Chaldees sent an army who put the land under fire and sword, broke down the walls of Jerusalem, demolished her palaces, destroyed her Temple, and carried away into captivity the remnant of the people. Thus, amidst the wails and warnings of prophets, the jeers and taunts of heathen nations, and the confusion and noise of warfare, the ruin of the kingdom of David and Solomon was consummated. The kingdom of Israel fell first under the yoke of Assyria, and after a hundred and twenty years of struggle and trial the kingdom of Judah succumbed to the conquering arms of the Babylonians. The captives were transformed into colonists, not treated as slaves. The loss they had sustained became perceptible to them when they found themselves without Temple or worship, Sabbath-day or festival season, and by the rivers of Babylon they wept when they remembered Zion. Daniel became a pattern of righteousness in a strange land, and Hadasseh (Esther) protected the Jews from suffering from a base plot—an incident still celebrated at the feast of Purim.

When all the old, and many even of the young, who had been dragged away from the land of their fathers, had expiated by death their hardness of heart and faithlessness of spirit, a train of Jewish exiles were permitted by Cyrus, king of Persia, the conqueror of their conquerors, to return and to build up the walls of Jerusalem. Under Sheshbazzar or Zerubbabel, Ezra, and Nehemiah, a portion of the nation made its way to the old land, and the two last, as actors in the important work, record the progress of the restoration of the holy city and its temple, and the joy with which they took possession of their fathers' land, and felt that the glory of their national history depended on their obedience to the laws under whose restraints their fathers were restive. Nominally, the twelve tribes were reunited and their ancient institutions restored; but many of the Jews remained in subjection to Persia until the conquests of Alexander the Great. After his death they submitted to his successors in Egypt and Syria. Those who remained in Assyria kept up tenaciously their national peculiarities, and became known as the Dispersion. Of these some ultimately apostatized and were absorbed in the general populace of that idolatrous empire; some returned and threw themselves fervently into the Hebrew national life, while those Israelites who had been left in Samaria coalesced with the colonists whom Esarhaddon had sent to people the waste places. Under the world-empire of Alexander, Palestine enjoyed peace, and after his death was made part of Syria. As Judea it was at length annexed to Egypt, and under the Ptolemies grew in numbers, increased in wealth, and took high rank in commerce. Many went forth as colonists to various parts of Africa, Syria, Asia Minor, and Greece, and being subjected to Hellenic influences had their holy books and history translated into Greek. Antiochus the Great made war on Egypt to recover Palestine, but was defeated by Ptolemy IV. at Gaza. In consequence of their refusal to permit Ptolemy to enter within the Holy of Holies he persecuted the Jews; and they, when Antiochus annexed Cœle-Syria, Phœnicia, and Palestine, submitted to him. Then there arose political and religious complications—Jewish straitness and Hellenic advocacy of freedom of thought and manners came into collision, and the *ungodly* and the *pious* were formed into parties. Ptolemy again acquired mastery in Palestine, and when Antiochus would have pursued to the utmost limits a retaliatory war he had begun, the Romans intervened. By the advice of Hannibal he engaged in war with Rome. Successful at first, he was checked at Thermopylæ and defeated at Magnesia. He was slain at Elymais in a popular insurrection. Seleucus IV. (Philopator), his successor as king of Asia, was in his general policy conciliatory to the Jews; but was murdered by one of his own courtiers, Heliodorus, who usurped the crown. Antiochus IV.—who had been released from durance as a hostage at Rome by Seleucus' sending his own son Demetrius as his substitute—expelled the usurper, and, excluding his nephew, seized the throne. He favoured the Greek party; the nationalists revolted; Mattathias and his sons, the Maccabees, organized their resistance in defence of Israel's faith and worship. Terrible woes were endured by the heroes of Jewish independence before they could occupy Jerusalem and purify the Temple. The news of their successes fell upon the ear of Antiochus, surnamed by some Epiphanes, the Illustrious, and by others Epimenes, the Mad, as he lay dying at Tabæ in Persia.

The accession of Demetrius I. (*Soter*, *i.e.* the Saviour), who, having claimed freedom from the Romans and been refused, hurried secretly from Rome to Tripolis and was recognized as sovereign of Syria, brought new troubles to the patriots. He sent Nicanor against Judas the Maccabee, but he was defeated first at Capharsalama, and again near Bethhoron he was vanquished and slain. In a fresh invasion Judas, fighting against desperate odds and treacherously deserted by his forces, perished bravely at Eleasa. Recovering from their disorganization, the patriots rallied and called Jonathan *Apphus* (the Cautious), to the leadership. He

opposed Bacchides in several campaigns, and so defeated him at Bethbasi as to be able to impose terms of peace. A struggle arose concerning the sovereignty of Syria between Demetrius and Alexander Balas, who was supported by Rome. The Maccabees accepted the latter, and gave him aid in the destruction of Demetrius. But when, yielding to self-indulgence, Balas weakened the attachment of the Syrians to him, Demetrius II. (*Nicator*, *i.e.* the Victorious) made a descent on that land and was crowned at Antioch, Jonathan agreed to supply him with a bodyguard of Jews if he would remove the Syrian troops from Jerusalem. Demetrius evaded the treaty; Jonathan then promoted the claims of Antiochus VI., and acquired the position of a trusted general. Tryphon treacherously lured Jonathan to Ptolemais, and put him to death in Gilead. Shortly afterwards, embruing his hands with his sovereign's blood, Tryphon usurped the throne of Antiochus. Simon, the last of the Maccabees, was chosen leader of the pious. He fortified Jerusalem, foiled Tryphon's invasion of Judea, and made alliance with Sparta and Rome. Demetrius II. offered amnesty and independence. Religion was reformed, the Temple repaired and enriched, commerce revived, and Judea was formally recognized as a nation. Simon gained favourable regard for the Jews at Rome, and devoted his efforts to the arrangement of the internal administration. He, with two of his sons, was murdered at Dôk by his son-in-law, Ptolemy, who aimed at the crown. John Hyrcanus, eldest son of Simon, had escaped assassination. He at once assumed sovereignty; but being hard pressed by Antiochus VII., he made a brave resistance and secured honourable terms. On the death of Antiochus, in an expedition against Parthia, Hyrcanus was able to reduce Idumea, to compel the submission of Samaria, and to free Judea—now including almost all the territories of Palestine west of Jordan—from Syrian domination. But with this renewal of Jewish nationalism, faction became more bitter and intense. The Pharisees and the Sadducees, by their ambitious contentions and partisan policies, disturbed the prosperity of Judea. Aristobulus I., the Phil-Hellenist, the first king of the monarchy of Judea since the carrying away into Babylon, succeeded in annexing Iturea, but having murdered his favourite brother Antigonus, died of remorse. His brother and successor, Alexander Jannæus, began a series of aggressive wars and regained the territories of the twelve tribes. The kings of Cyprus and Damascus opposed his conquests. The Arabians defeated him in Gaulonitis. His subjects rebelled and he was driven from his kingdom. He reattained his throne and crucified 800 opponents. On his death he left his kingdom to his wife, Salome. She favoured the Pharisees, and by the might of her arms maintained the integrity of her dominions. Aristobulus II., after taking part in a revolution and seizing the crown, was besieged in the Temple. In the warfare of the Ptolemies and the Seleucids, which was now drawing to an end, Judea was again entangled. Pompey called Aristobulus and his brother to submit their case to his arbitration. The monarch, anticipating an adverse decision, fortified the Temple. Pompey besieged him for three months, and on a Sabbath entered it, massacred 12,000 Jews, and dismantled their fortresses. He appointed Hyrcanus ethnarch of Judea—Judah and Benjamin—and made him a tributary to Rome. Samaria he organized into an independent state, and annexed Galilee to Roman Syria. Among the prisoners with which he founded the Jewish colony of Rome were Aristobulus and his two sons. Gabienus, who held the proconsulate of Syria, reorganized Judea as a part of his province, and Crassus, as a preparative for a war against Parthia, robbed the temple of the Jews. Julius Cæsar induced Aristobulus to go to Syria, and as claimant of the throne of Judea create a diversion in opposition to Pompey, but he was poisoned on the journey thither. Near Pharsalus Cæsar defeated Pompey and became master of the world. He made Antipater, the Idumean, procurator of Judea, Galilee, and Samaria—with power to fortify Jerusalem, and with conservation of the ethnarchy and high priesthood to Hyrcanus. Antipater appointed his sons, Phasuel and Herod, respectively governor of Jerusalem and tetrarch of Galilee. Herod repressed the banditti in his district, and, with the help of Sextus Cæsar, proconsul of Syria, opposed the priesthood. Herod artfully ingratiated himself with Cassius after Cæsar's death, and by betrothing Mariamne, granddaughter of Hyrcanus, conciliated the Jewish king and people. After Philippi, Herod gained from Antony, for himself and his brother, the tetrarchy of Palestine; but Antigonus the Asmonæan opposed, and with Parthian aid defeated him. Herod, with Mariamne and her mother, escaped to Masada and thence to Egypt. Cleopatra offered him the command of her army, but he refused and proceeded to Rome. There the senate made Herod "King of the Jews." With the aid of the Romans Herod took Jerusalem and established his authority in his realm. He visited Octavian at Rhodes, after Actium, won the favour of the conqueror, and was confirmed in his position as king. He introduced Greek and Roman customs and habits, theatres, amphitheatres, gladiatorial shows and games, filled the kingdom with monuments of magnificence and taste, rebuilt the Temple, and kept constantly improving it year after year. An insane mania for murder seems to have seized on him and made domestic life a bane. He executed Mariamne and her mother Salome, Hyrcanus, and all the surviving members of his family. An almost equally maniacal remorse goaded him to untold cruelties. The slaughter of the babes of Bethlehem, and his order that the nobles who witnessed his death should be executed immediately thereafter, that universal mourning might attend his obsequies, are examples of what bloody murders stained his latter days. By will he left the kingdom of Judea, Samaria, and Idumea to Archelaus; Galilee and Perea he gave, as a tetrarchy, to Herod Antipas, and to Philip, Iturea, Gaulonitis, Trachonitis, and Batanea. Herod Antipas died in exile. Herod Philip II., son of Herod and Cleopatra, died at Bethsaida-Julias. Archelaus was banished for tyranny to Vienne in Gaul, and committed suicide. His ethnarchy was absorbed into Roman Syria, and Quirinus or Cyrenius (a second time legate) enforced the census-taxing. Pontius Pilate, by favour of Sejanus, was appointed procurator of Judea. All things being ripe for a great change in the history of the race, the Messiah came, and the Church of Christ—a spiritual temple—rose to replace the Temple at Rome-destroyed Jerusalem.

GEOGRAPHY.—CHAPTER VIII.

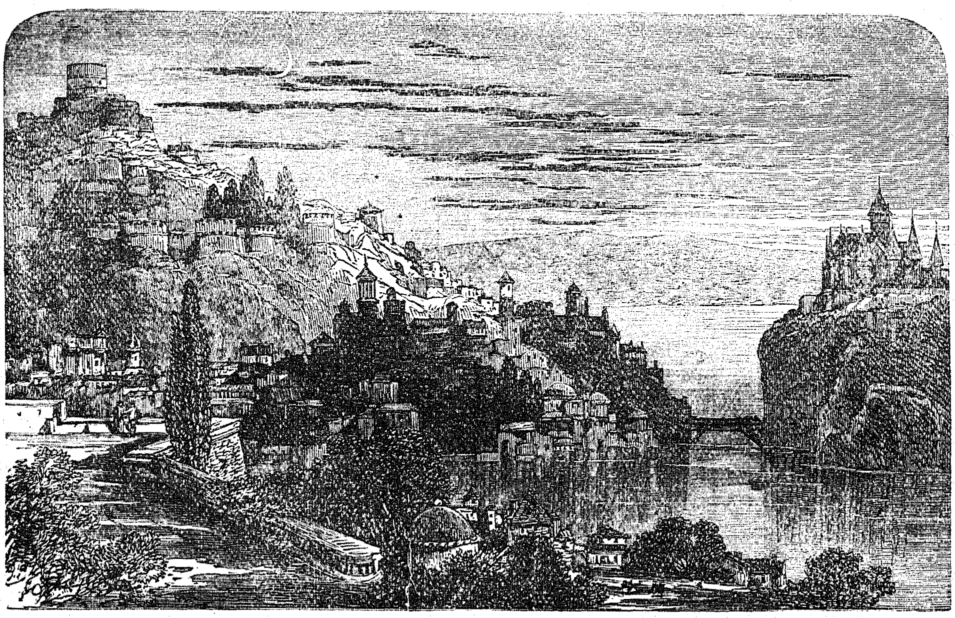
COUNTRIES OF ASIA DESCRIBED—ITS ISLANDS AND LAKES—INHABITANTS—VEGETABLE, ANIMAL, AND MINERAL PRODUCTIONS, ETC.

RUSSIAN ASIA consists of (1) Siberia, (2) Transcaucasia, and (3) Western Turkestan.

1. *Siberia* extends from Europe to the Pacific Ocean, and from the middle of Asia to the Arctic Sea. It occupies, in fact, the whole of the north of Asia from 47° to 78° lat., 60° E. to 170° W. lon., an area of 5,600,000 square miles, upwards of thirty times that of the British Isles. It is principally watered by three gigantic rivers:—Obi, in the west, which receives as tributaries (1) Tam-Ket, Vakh, and Irtish, and (2) through the Irtish (which is really larger and longer than the Obi) Om, Ischim, Tobol, and Tavda, &c., and falls into the Arctic Sea; Yenesei—which, formed by the junction of the Oulon-Keme and the Bey-Keme, proceeds from the northern frontier of China, and flows almost due north through the centre of the country to the Arctic Sea; Lena—whose tributaries are (1) Kireugh, Vitim, Olekma, and Aldan on the left bank, and (2) Vilui and Bakania on the right—rises in Lake Baikal, passes Yakutsk, and by many mouths flows into the Arctic Sea. The lower courses of these rivers are frozen for the greater part of the year. The chief elevations in Siberia are the Altai Mountains, which stretch for about 2000 miles along 50° N. lat. They consist of prolonged, wavy, rolling ridges, divided by high plains or wide valleys. Many branch chains run off from the mainland, and many lakes are formed in their hollows. Snow covers their sides, and glaciers glitter on their summits. The mineral treasures of the region of the Altai are varied and rich; the topaz, amethyst, onyx, jasper, cornelian, &c., are among its gems, and of the metals, gold, silver, copper, lead, and iron are found in it. Mines of these metals have been worked by an unknown race i

olden times. The alder, aspen, acacia, birch, cedar, fir, larch, and willow are among its trees, and upon the slopes the banquetin, chamois, deer, marmot, and wild sheep abound. Seaward, the land is desolate, swampy, and unculturable. In the centre, grass, shrubs, and a few dwarf trees grow, and, in some favoured localities, cereal crops and vegetables. Fine fertile tracts are found in the spaces in the south not occupied by dense forests. Skeletons of the rhinoceros and the mammoth in a fossil state are plenteous in the valley silt. Siberia is divided into two vast regions, each of which has a governor, and each of these regions is again subdivided into minor governments. Tobolsk, Omsk, Tomsk, and Yeneseisk are the chief towns in Western, and Irkutsk and Yakutsk in Eastern Siberia.

2. *Transcaucasia*, or Russia beyond the Caucasus, occupies the land lying between the Black Sea and the Caspian Sea, and running along the grand mountain-chain which, in a diagonal-wise course of 700 miles, joins one sea-basin to the other on the northward of the territories of Turkey and Persia. The modern governments are called Kutais, Tiflis, Shamaki, and Derbend; but the old names of these lands are often yet used—Abassia, Mingrelia, Imeritia, Georgia, Shirwan, and (part of) Armenia. Their area is 86,000 square miles. *Abassia* is that narrow strip which margins the Black Sea on the north-east. There are many highland villages, but no towns in this territory. The heroes who fought for the freedom of the Caucasian hill-ranges are celebrated in ballad and song. *Imeritia*, part of the ancient Colchis, annexed in 1810, lies inland to the east of *Mingrelia*, a maritime district in the south of the Caucasus; both are comprised within the basin of the Rion (or Phaz, the ancient *Phasis*). It is said to be the native region of the pheasant (*phasianus*). *Georgia* is a finely diversified country, having the Caucasus on the north and west, Shirwan on the east, and Armenia on the south, occupying the central portion of the valley of the river Kur, which receives tributaries from the hill-lands around, and flows into the Caspian Sea. The greater portion of the Georgians are Christians connected with the Greek Church. *Shirwan* is the territory between Georgia and the Caspian. It is a fertile plain, watered by the lower reaches of the Kur. *Armenia*, so far as it is yet Russian, is divided from Georgia on the north by the Kapan Mountains. In the south-west rises Mount Ararat (*Agri-dagh*), 17,260 feet. It also contains the large fresh-water Lake Gonkcha (*Sevan* or *Erivan*), 5300 feet above the sea level, connected by the Zingui with the Aras, a large, rapid, steep-banked river which forms the southern boundary of Russian Armenia. In the mountain-districts many of the tribes in Transcaucasia are practically independent. Tiflis, the seat of the government of Georgia, is on the right bank



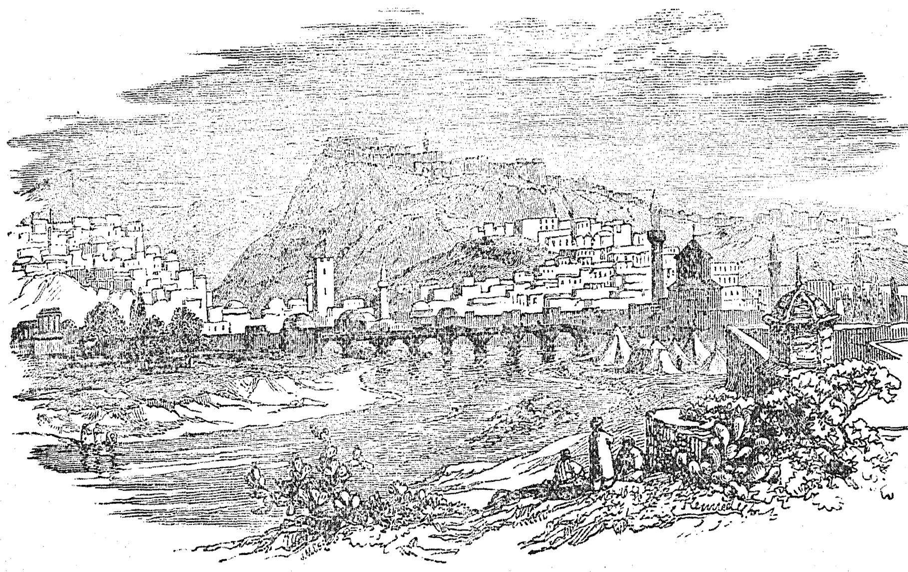
Tiflis.

of the Kur. The Pass of Dariel, which crosses the range of the Caucasus, reaches this length, and here the Kruzberg, or Mountain of the Cross, commemorates its completion in 1809. Erivan is the chief town of Armenia. Baku, in Shirwan, on the shores of the Apcheronese peninsula in the Caspian Sea, is fortified and has a considerable trade. Kutais, in Imeritia, on the banks of the Rion, is a small town of some mercantile importance. Kars—which in 1855 General Williams defended gallantly for six months, and was (with a district of 5670 square miles) ceded to Russia by the treaty of Berlin in 1878—has strong fortifications, built chiefly of black basalt, and stands 6000 feet above the sea level.

3. *Trans-Caspian Russia*, or Western Turkestan—the land of the Turks—extends from the south-west boundaries of Siberia to the mountain-ranges which form the northern border of the plateau of Iran. The basin of the Aral is included in it. In the north is the extensive steppe of the Kora-Kirghiz. A high barren plateau between the sea of Aral and the Caspian Sea rises 640 feet, and is bounded on the south by the desert of Khorasan and Khiva to the west of the Oxus. The deserts of Kizil-Koum and Kara-Koum, with the course of the Sihoon dividing them, lie east of Aral; and all the east part of Turkestan, towards the great central plateaux, are hill-lands with fertile plains and valleys between them. Afghanistan, Persia, and the Hindu-Kush mountains form the southern boundary. It stretches from the Caspian to the Thian-Shan (Heaven-seeking) ranges, 1200 miles off, which form the east separation between Turkestan and China, where the Pamir Steppe ("the roof the world") stretches for 1000 square miles its snow-clad heights. The central quadrangle of Asia constitutes the territory subject to Russian administration. It is divided into three provinces—*Ferghana*, formerly the Khanate of Khokan, stretching along the upper and middle courses of the Sihoon, having Tashkend for its capital; *Zerafshan*, previously called the Khanate of Bokhara, lying along the mid-course of the Amoo, with the ancient Samarcand, where Tamerlane once reigned, for its capital; *Khiva*, an old khanate along the eastern margin of the Caspian, a strongly fortified centre for the caravan-traffic through the mountain ranges of Tibet and China, with Khiva for capital.

Turkey in Asia.—The Ottoman Empire in Asia is much more extensive than in Europe. The eastern side of the

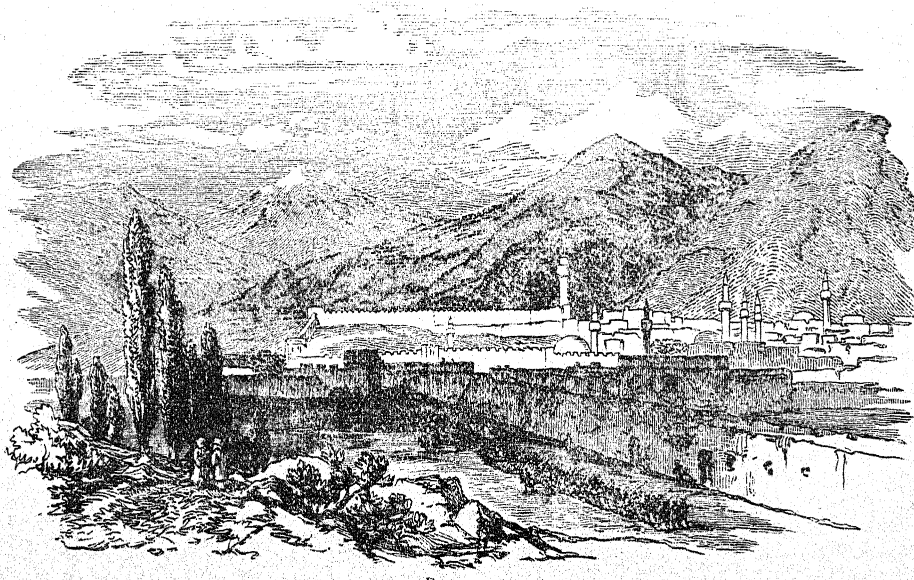
Greek Archipelago, the southern shores of the Black Sea, the northern coast of the Persian Gulf, and the Levantine portion of the Mediterranean form its water boundaries, but its land frontier is rather indefinite. From Ararat to Cape Baba it stretches east and west about 950 miles. From Scutari on the Straits of Constantinople, in a diagonal line, to the head of the Persian Gulf, it extends about 1400 miles. It comprises in an area of 729,380 square miles Asia Minor, Syria (including Palestine), part of Armenia, Kurdistan, Mesopotamia, the western portion of Arabia bordering on the Red Sea, and the district of El Hasan on the north-eastern part of the Persian Gulf.



Kars.

Asia Minor (the Less) is a peninsular projection from the main mass of the Asiatic continent towards Europe. Its coast line exhibits bold headlands, splendid rock scenery, gulfs and bays. The Taurus chain stretches east and west and sends off spurs, on which the waves of the Levant lave or dash. The highest point in this range is a snow-crowned volcanic cone, Mount Arjish, 13,100 feet high. The Plain of Kutaiah is treeless and dry, with here and there good pasturage, and rises 6000 feet above the level of the sea. Parallel to the Black Sea there runs for 100 miles in length by 40 broad a range called *Agatch Degnis* (the Sea of Trees) which supplies timber for shipping. In the interior, in the Plain of Konieh, is the shallow salt lake of Koj-hissar, nearly 90 miles in circumference.

Syria (probably originally called *Tsyria*, the land of *Tsyr* or *Tyre*, and mainly the *Aram* of the Bible) extends from the Mediterranean to the Euphrates. On the west it is mountainous, and in the northern part its mountain-lands form two long chains; the seaward range is the Libanus (Jebel Libnan), and its parallel range is Anti-Libanus. These are separated by the valley of Cœle-Syria, through which the river Leontes flows. More northerly still, a hilly coast region



Erzeroum.

fronts the sea, while a long retiring valley, watered by the Orontes, lies behind. The south-west portion of Syria is Palestine, to the southward of Mount Hermon (Jebel-esh-Sheikh, or Old-Man Mountain). The Syrian and Arabian deserts bound it on the east and south. Its most remarkable feature is the long narrow valley of the Jordan, a deep ravine terminating in the Dead Sea. On either side of this valley a succession of elevated plains appear, some portions of which

are distinguished as mountains—*e.g.* the promontory of Carmel, on the coast of Galilee; the south boundary of the Bay of Acre, 1200 feet; Mount Tabor, a conical hill in the interior, rising 1000 feet above the plain at its base; Ebal and Gerizim, on either side of the fertile valley of Shechem in Samaria; Mount Quarantana, in Judea; and in the east of Jerusalem, the Mount of Olives, 2724 feet, which itself stands on a plateau 2000 feet above the sea-level. The Plain of Esdraelon is in the southern part of Galilee; that of Sharon stretches from Carmel to Joppa, and on the western slopes of the hill country, between the central table-land and the sea, is the Plain of Judæa. The Waters of Merom, the Lake of Galilee, and the Dead Sea are its chief lakes. Few of its rivers are perennial, but the Yarmouk and the Jabbok, flowing into the Jordan, the Amon into the Dead Sea, and the Kishon and the Belus, falling into the Mediterranean, may be named among these.

Turkish Armenia is a succession of high mountain lands and lofty valleys, situated between the basins of the Euphrates and Tigris, the boundaries of which are not well defined either naturally or politically. Erzeroum, its ancient capital, is 5800 feet above the level of the sea, is strongly fortified, and was formerly the centre of a large trade, which has greatly diminished in recent years owing to Turkish misrule.

Kurdistan is a continuation of the Armenian hills in a southerly direction, on the east of the Tigris, stretching to the borderlands of Persia. Its highest point is Bisutan, 12,000 feet. Here manna (*Kudret-halvassiz*, or the Divine sweetmeat) is found on the leaves of the dwarf oak, the flowering ash, &c. The different kinds of oak flourish on the slopes of its hills, and afford the finest gall-nuts. Van, on the south-east of Lake Van, is regarded as the city of Semiramis; Mush, on the White River (*Ak-su*), Diarbekr, Mosul, Bitlis, and Julamuk are its chief towns.

Mesopotamia, or Syria of the Two Rivers, called also Padan-aram ("the Plain of Syria"), is now known as *Al Jezirah* ("the peninsula"), from its being almost surrounded by water. It occupies the hollow between the upper courses of the Euphrates and the Tigris near Telek, and lies between lat. 35° to 37° 30′. The lower part of this inland peninsular tract, from the great bend of the Euphrates to the confluence of the two rivers, is called Irak-Arabi, and the whole district nearly corresponds to the ancient plains of Assyria and Babylon. The upper plains are, though sometimes well-wooded, mostly barren; but the lower plains, where they border on the Persian Gulf, are naturally fertile. From the west of the Euphrates the Syrian desert extends to the mountain region of the Syrian coast. It is divided into two pashalics—Urfah and Bagdad—of which, besides capitals of the same names, Bir, Sumiezat, Rakka, Hillah, Kurnah, and Bassorah are the chief towns.

Arabia.—This great south-western peninsula of Asia exceeds in area 1,000,000 square miles. The Syrian desert bounds it north, the Gulf of Oman and the Persian Gulf west, the Indian Ocean south, and the Red Sea or the Arabian Gulf east. A narrow belt of low land, called Gaur or Tehama, extends along the coasts; a mountain region then rises, and in the interior there are a series of high desert plateaux. Arabia has no proper perennial rivers, but many springs and occasional water-courses occur among the mountain-valleys and in the oases. It was anciently divided into the three parts—Petræa, north-west; Felix, south-west; and Deserta, in the midland. The modern division is sevenfold—(1) El-Tour Sinai, the district around Sinai; (2) El-Hejaz (*Holy Land*), along the coasts of the north-west; (3) Yemen, in the south-west; (4) Hadramaut, along the southern shores; (5) Oman, in the south-east; (6) El-Hassa, on the shores of the Persian Gulf; and (7) Nedjid, in the interior. The town and promontory of Aden, rising high and rocky 1776 feet, connected by a narrow isthmus to the mainland, is a British possession, used as a coaling station for steamships, and is garrisoned.

Persia, called from remote antiquity by the natives Iran, is the largest, richest, and most powerful of the kingdoms of Western Asia. In the west and north it is traversed by mountain-chains rising 12,000 feet, and the peak of Demavend attains an elevation of 18,470 feet; but the central and eastern portion is a great salt desert. It has neither natural landmark nor distinct artificial boundary, though, roughly speaking, Turkestan, the Caspian Sea, and Russian Armenia border it north, the Persian Gulf and part of the Arabian Sea south, Turkey in Asia west, and Afghanistan and Beloochistan east. The Caspian Sea affords it a commercial route to Russia, and the Persian Gulf to India. It has scarcely a navigable river except the Karun, 260 miles. It and the Kerkhah (*Choaspes*), 380 miles, are tributaries to the Euphrates. The little, song-famous Bendemir stream flows into the salt Lake of Bakhtegan in the south. Its chief divisions are:—(1) Azerbijan (*Land of Fire*), north-west. In it are the peak of Savalan, 13,000 feet, and the great salt Lake of Urumiah. Tabriz, its chief town, is, through Turkey, the emporium of commerce with Europe. (2) Ghilan and Mazanderan, on the southern shores of the Caspian and along the roots of the Elburz, are small in extent. Resht contains many bazaars. Sari is a well-built town. (3) Luristan and Khuzistan, south-west, the latter of which is the Shushan of Esther and Daniel; Shuster (*Susa*) is the capital, and Dizful is the largest town. (4) Fars, Laristan and Kerman, south; Shiraz is the chief town, 118 miles inland from Bushire, the principal seaport of Persia. (5) Khorassan, east and north-east, including a part of Kurdistan, is almost a desert; Meshid in the north, in the midst of a fertile plain, is inclosed by walls 7 miles in circuit; Astrabad is at the south-east corner of the Caspian; Yezd, on an oasis in the Great Salt Desert, is a caravan station. (6) Irak-Ajemi, in the centre and west, though last-named, is first in rank, and possesses both the old and the new capitals—Ispahan and Teheran. The west of the province is traversed by the Zagros Mountains, and the Holvan, in its course to the Tigris, contributes fertility to its banks. Teheran is 70 miles from the Caspian, has large and numerous bazaars, and is the seat of government. Ispahan is 226 miles distant in the south part of the province, in a fine plain watered by the Zenderud. Its manufactures and commerce are extensive and varied. The sovereign (*Shah*) is designated *Kibla-e-Alem*, *i.e.* "the centre of the universe," or "the point of the world's adoration."

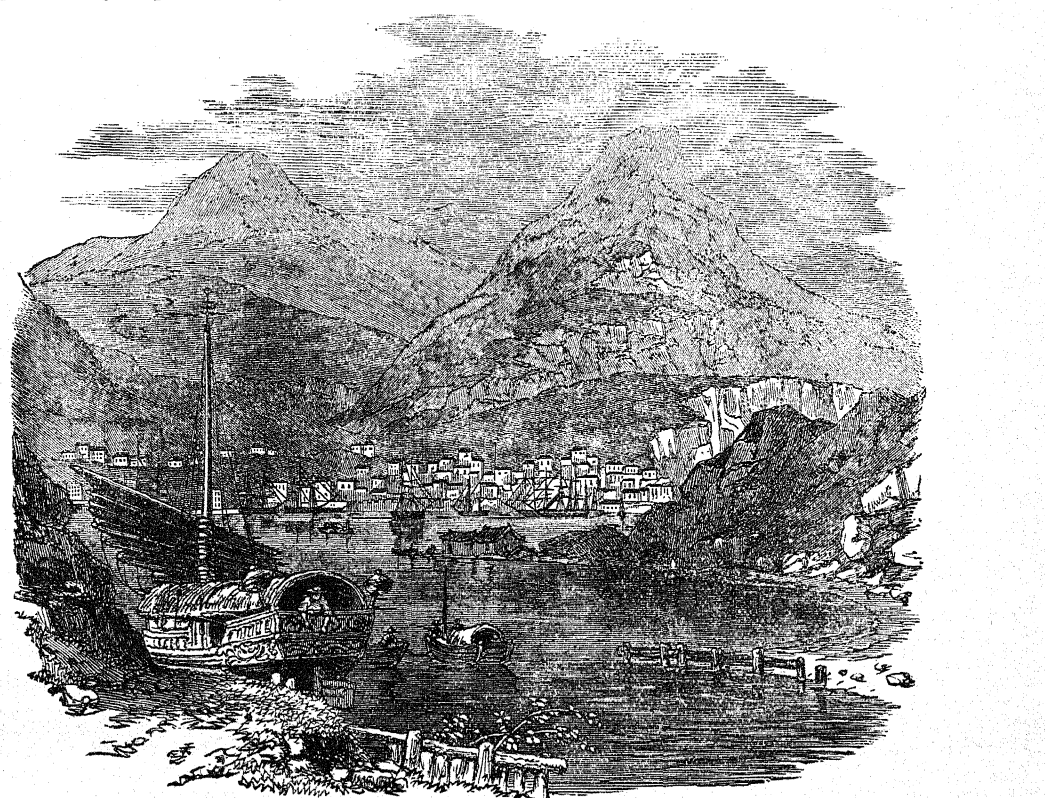
Beloochistan is a rugged, poor, barren country, rather larger than Great Britain. The Kurkelei Mountains, running parallel with the shores of the Arabian Sea, descend in terraces towards the coast. The Hala range stretches northward from Kurrachee parallel with the course of the Indus to the Bolan Pass—a narrow defile 51 miles long. The plateau within these ranges is desert and bare; it has no rivers, but in the rainy season torrents rush down the gorges of the hills. Through it (*Gedrosia*), Alexander the Great marched his army when returning from India. Britain has secured right of communication through its hill-passes. Kelat, Sharawan, Quetta, and Kutch-Gundava, in the north-east, and Jhalawan, Luz, and Makran, in the south, are the chief towns. Almost the whole of Beloochistan is now included in British India.

Afghanistan, immediately to the north of Beloochistan, is somewhat larger than France. The west and south-west consists of sandy wildernesses, with a few bright oases. The east and north-east is a series of elevated terraces, from which mighty mountains rise towards the Hindu-Kush range, which divides this territory from Russian Turkestan. The country is walled in on the east by the Suleiman Mountains, in which the four main passes for trader, pilgrim, or conqueror to and from India are found, viz.:—(1) Khyber, round the north of the range, up Cabul River, and along the Khurd Cabul Pass; (2) Shutagarden, up the Kurrum valley; (3) Gomul, across the centre; and (4) Bolan, through northern Beloochistan. The three chief states are Cabul, Kandahar, and Herat. The first is a fortified city, on a plain 6400 feet high, and contains Bala-Hissar, the residence of the Ameer; the second, 280 miles south-west, is defended by a fortress situated on a lofty precipitous rock, and has considerable trade and manufactures; the third is in the centre of miles of desert, nearly 400 miles from Cabul. Herat is the key of Afghanistan on the west, and it commands the only available route for military forces to or from India. Hence the interest taken in the "scientific" political frontier of this territory.

India [will be treated of as part of The British Empire].

THE CHINESE EMPIRE.—This territory includes nearly one-fourth of the entire extent of Asia. It is inclosed by Asiatic Russia north, India and the Indo-Chinese Peninsula south, Turkestan west, and Pacific Ocean east, and is as large as all Europe. It comprises China proper, Mantchuria, Mongolia, Kulja, Kashgaria, Ko-ko-nor, Tibet, and the large island of Hainan. It is the third empire in extent and the most populous in the world. Totally different features characterize its immense districts. Rich-soiled alluvial plains contrast with thinly-peopled wastes, and co-exist with vegetationless tracts of sand or shingle, unbroken for leagues, except by low hills and rocky ravines.

China, by far the most important and populous, is the nucleus. It lies between 20° and 41° N. lat., and 98° and 124° E. lon. Its land-frontier is 4400, coast-line 2500, and area 1,300,000 miles. It is separated from Tartary on the north by the Great Wall, Tibet is on the west, Burmah, Laos, and Annam on the south, and on the east and south-east it is laved by the seas of Okhotsk and Japan, the Yellow, the Eastern, and the Chinese Seas. Its western surface, especially towards Tibet, rises into hills with forest-clad slopes and snow-capped peaks; but in its southern districts it is beautifully varied by terraced hills, clothed with forest and plant-life. Its northern portion is perhaps the most permanently productive grain-plain on the globe. All the low swampy grounds are used for the raising of rice, and no spot capable of supporting vegetable life is left uncultured. The tea-plant—*Thea viridis* and *Thea bohea*—grows in almost every province. The Hoang-ho is a turbulent, furious river, which, because it often broke its banks, an emperor called China's Sorrow; and the Yang-tse-Kiang, the favourite of the Chinese, is calm, ample, and majestic, and readily lends itself to transport and navigation. China is divided for administrative purposes into eighteen provinces:—I. Five northern—(1) Chih-le, (2) Shang-tung, (3) Shan-se, (4) Shen-se, and (5) Kan-su, of which the respective capitals are Pekin, Tsi-nan, Tai-yuen, Sin-gan, and Lan-chow; II. ten central—(1) Kiang-su, (2) Ho-nan, (3) Gan-hway, (4) Hu-pe, (5) Sze-chuen, (6) Hu-nan, (7) Kwei-chow, (8) Che-kiang, (9) Fu-keen (from which Formosa was separated on its cession to Japan), (10) Kiang-se, whose chief towns are Nankin, Kai-fung, Ngan-kin, Vou-chang, Ching-tow, Chang-sha, Kuei-yang, Hang-chow, Fu-chow, and Nan-chang; III. three southern—(1) Kwang-tung, (2) Kwang-se, and (3) Yun-nan, having Canton, Kuei-ling, and Yun-nan for capitals. Each province is subdivided into districts, departments, and circuits. The towns have little variety in architecture and arrangement. Their irrigation works give occasion for many canals and bridges. The British and Portuguese have possessions in the south. The island of Hong-kong, and the opposite peninsula of Kow-lung—of which the chief town is Victoria—have been ceded to Britain. *Mantchuria* is the native seat of the reigning dynasty. It extends from the Great Wall to the Amoor in the north-east.



Hong-kong.

Corea is a mountainous peninsula, having an area of about 80,000 square miles. It was tributary to China before the war with Japan in 1894-95, but is now nominally independent.

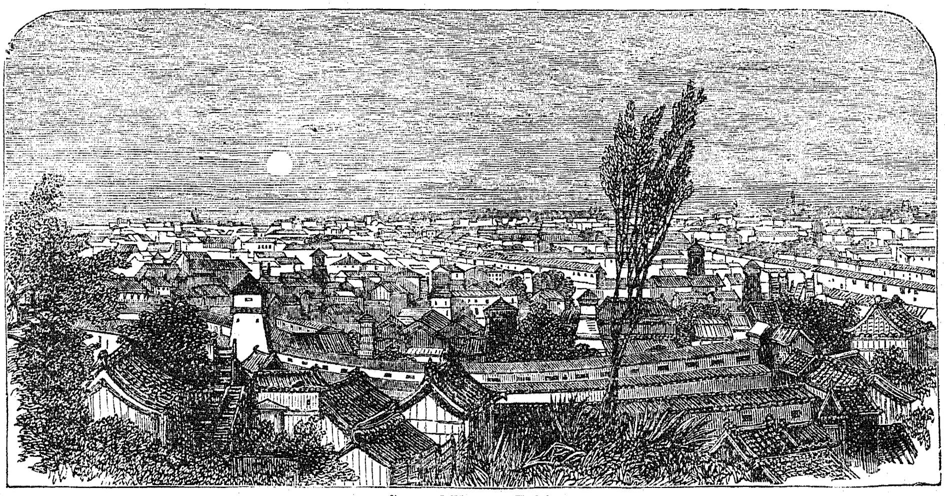
Mongolia, formerly the central seat of the empire of Genghis Khan, is sometimes designated Western Tartary. It occupies an immense space between Siberia and China proper. The "naked desert," Gobi, 300,000 square miles, a frightfully sterile part of the rainless tract of the Old World, lies in a hollow 2740 feet below the general height of its plateau (nearly 7000 feet), and crosses it from east to west. *Maimatchin*, separated by 280 yards of neutral ground from the Siberian town of Kiachta, is a trading town.

Tibet is the south-west portion of the Chinese Empire, and the largest and highest plateau on the earth, from 10,000 to 15,000 feet in elevation. It is inclosed by the Kuenlun and Himalaya Mountains on the north and south. It is furrowed with valleys, and from it many of the great rivers of Asia flow—*e.g.* Indus, Sutlej, Brahmapootra, Yang-tse-Kiang, Hoang-ho, &c. It is subdivided into Great, Middle, and Little Tibet. Lassa, the residence of the Dalai-Lama, the pope of Buddhist worship, is the capital of Great Tibet.

Chinese Tartary, or Kashgaria, sometimes called Eastern Turkestan, is a part of the table-land of Mongolia. On the south the great Kuenlun range, on the west the Pamir

plateau, on the east Gobi, form its boundaries. It is intersected by the Celestial Mountains, running east and west, and dividing it into the two districts of Sungaria, north of the Thian-Shan, and Dzemgaria, south of the Thian-Shan. Kashgar is the chief town, but Yarkand is the more important place in the latter, Kuloja in the former.

THE JAPANESE EMPIRE consists of an elongated curving archipelago. It is the insular sovereignty on the eastern outskirt of Asia, corresponding to the insular monarchy in the west of Europe. Its coasts are generally much broken up, and the surrounding waters are studded with innumerable picturesque islets. The islands are mostly volcanic and mountainous. Not more than one-sixth of its surface is capable of cultivation. Yeddo (Yôkiyô), now called Tokio, includes 125 villages, covering 15 miles from north to south and 11 from east to west. It is the residence of the Mikado



General View of Tokio.

("Venerable"), and the actual capital. The government is a constitutional monarchy. Its port is Kanagawa. At Yokohama there is a granite pier and quay, and there the foreign merchants reside. Kiyôto, an inland city 200 miles west, is the old capital. It is near the largest lake in Japan—Biwa, or Otsu, 60 miles long by 20 broad, on which small steamers ply. Osaka is the commercial capital, and Hioga is its port. Osaka is the Paris of Japan, but resembles Venice in being intersected by canals. Sixty miles from Tokio the sacred mountain of Fuyi-yama ("Rich Scholar Mountain") rises to a height of 17,365 feet.

ISLANDS.—The insular appendages of Asia are very numerous and closely adjoin the mainland. They occur chiefly in groups, and seem to be both of coralline and of volcanic origin. They have an aggregate area equal to nearly one-fifth of the surface of Europe. The *Aleutians* are a group of small rocky volcanic isles stretching in a curving line between the extremity of Kamschatka and the promontory of Aliaska in North America; the large almost peninsular island-strip of *Saghalien* (Tarakai) lies off the east coast of Tartary, and is 600 miles long, with a breadth varying from 25 to 120 miles; the *Great and Little Kurile Islands* are a cold and sterile volcanic group between Kamschatka and Japan, in which some peaks are thrown up to a height of 6000 feet. Nearly 4000 islands are included in the Japanese series. The chief of these, Niphon, Kiusiu, Sikokof, and Yesso, constitute—with the dependent *Loo-Choo Islands*—the main portions of the ancient and extensive Empire of Japan, which altogether (including the Kuriles) comprises 148,000 square miles. *Formosa*, ceded to Japan on the conclusion of the war in 1895, is a large island on the south-east of China, 200 miles in length and 90 miles in breadth, and is divided by the mountain-chain of Tu-chan, whose peaks reach a height of 10,000 feet, into an eastern and western portion, the former of which is inhabited by Malays. *Hainan*, in the Gulf of Tonquin, is about three-fourths the size of Formosa. The ovate island of *Ceylon* (Taprobane) lies off the south-east coast of India, from which it is separated by Palk Strait in the north-east, and by the Gulf of Menaar on the north-west; and yet it is almost united to the Indian coast by the curious sandbank called Adam's Bridge, which, while it divides these two waters, affords a roadway more than halfway to the continent. The *Andaman Isles*, a group of volcanic origin like the Molucca and Sunda Islands, of which they seem to be a continuation, lie in the Bay of Bengal, and are inhabited by a race of Papuan negroes. The *Nicobar Islands* are coralline. The chief ones are Great Nicobar, Nancowry, Therese, Sambolong, Camorta, and Car-Nicobar. They are 120 miles north-west from Sumatra, and are inhabited by Malays. The *Maldives*, or Thousand Isles, are a chain of eighteen groups of coral *atolls* surrounding a central lagoon, stretching along the meridian 72° 30′ E. lon. and lying between 45° S. and 7° 6′ N. lat., inhabited by Mohammedans. The *Laccadives* are a similar and neighbouring group, of which only about twenty are of any considerable extent. Anderor, the largest, is little more than 6 square miles in area. On the west, in the Levant, is *Cyprus*, 44 miles from the coast of Asia Minor, and now a British possession. From east to west it extends 132 miles, and ranges from 30 to 35 miles in breadth. Monte Croce (*Olympus*), in the north-west, is 8000 feet high. Its chief towns are Lefkosia (or Necosia) and Larnaca.

LAKES.—The *Caspian* is a true lake, though from its magnitude it has been named a sea. It is the largest inland water in the world, 700 miles in length, running north and south, and averaging 200 miles in width from east to west; its surface extends to 178,866 square miles. It lies 83·6 feet below the level of the Black Sea. The *Sea of Aral* is likewise a receptacle of river-water, and is a lake without an outlet. It has an area of 26,000 square miles. Some islands discovered near the centre in an exploring expedition undertaken by Russia (1846–48) have been called "the Islands of the Czar." *Lake Serikol* is the highest sheet of water on the surface of the globe. At a height of 15,600 feet, almost equal to that of the peaks of Mont Blanc, it gathers up into a crescent-shaped hollow, 14 miles long and of an average breadth of one mile, the drainage of the pinnacles of the plateaux of Pamir. *Lake Baikal*, in Siberia —the "Holy Sea" of Russia—is 15,000 square miles, and is the largest fresh-water expanse in Asia. In winter the ice on its surface is extremely thick, and it then becomes the tea-traffic pathway between China and the Siberian shore. The *Dead Sea*, in Palestine, is 1300 feet below the level of the Mediterranean, and is divided into two basins of unequal size and dissimilar depth. The southern, and smaller, is about 18 feet in depth, while the northern and larger has a depth ranging from 1100 to 1300 feet. Its waters, which are dark blue, and in some places bottle-green, are, though pure and limpid, more bitter, acrid, and disagreeable than sea-water. The bottom is, near the shore, incrusted with

salt. The hollow which the Dead (or Salt) Sea (*Lake Asphaltites*) occupies is walled in on the east by steep terraced hills, a continuation of the mountains of Moab. The north shore is flat, the north-west sloping, the west is lofty and precipitous, and the south low and flat, allowing the waters to overflow El Ghor. *Urumiah*, in North Persia, is 80 miles long and 24 broad. Its waters, 4100 feet high, somewhat resemble those of the Dead Sea. It is said to contain no living thing, except an acotyledonous plant of the Fucus order, which, when thrown upon the shore, gives forth a noxious effluvia. *Lake Van*, or Ardjosh, in Asiatic Turkey, is embosomed among lofty mountains between Armenia and Kurdistan. It has an area of 1400 square miles, and is 5467 feet above the sea-level. *Lake Balkash*, or Tenghiz, is a large river-receiving lake, 150 miles long and 70 broad, in Independent Tartary.

Ethnography.—Asia has been the main region whence emigration has spread. Its population is almost entirely indigenous. It contains nearly two-thirds of the inhabitants of the earth. Drawing a diagonal along the Himalaya range, Hindu-Kush, the Caspian Sea, and the Caucasian Mountains, we roughly divide the territory of Asia into two portions, of which that on the south-west may be said to be chiefly inhabited by men of the white (or so-called Caucasian) race—Afghans, Arabs, Hebrews, Hindoos, Persians, Syrians, &c.; and that on the north-east by yellow (or Mongolian) races—Chinese, Indo-Chinese, Japanese, Kirghis, Mongols proper, Truchmenes or Turkomans, Tartars, &c. Malays occupy the peninsular and insular parts of the south, and some Finnic varieties inhabit districts in Siberia.

Botany.—There are six pretty well marked divisions of Asiatic vegetation:—(1) *Siberian*, comprehending the northern portion of the continent from Tartary to the Arctic Ocean. Here vegetation is limited, cereals are cultivated with considerable difficulty, and flowers are few. (2) *Tartarian*, where the elevation being great, the climate dry, and the atmosphere cold, the botanical species are distinct from those in the Siberian region, and not numerous. (3) *Cashmerian*, where sharp winters and fine warm summers abound; trees and flowers which require bright light and great heat are luxuriant, delicate, and plentiful. Fruits grow lusciously, cereals and culinary vegetables thrive. (4) *Syrian*, from Southern Persia to the Great Indian Desert, is arid and hot. Its want of water and scorching sunshine occasion a scantiness of species and a general feebleness of plant-life. (5) *Himalayan*, which has the south-west or Indian slopes clad with jungle, which Heber called "the belt of Death." Its south-east parts are tropical in vegetation, and its forest trees are numerous and varied. The wide range of differing climate causes a wide difference in the flora of nearly neighbouring districts. (6) *Indian*, or moist lands, where coffee, indigo, sugar-cane, palms, and other tropical products flourish, and where some of the most remarkable vegetation of this continent is found; and (7) *Malayan* or equinoctial, where fruit-trees, rich-leaved plants, and spices abound. Even a catalogue of the various plants of Asia would fill many columns.

Zoology.—The great diversity of climate and conformation, both horizontal and vertical, which marks the continent of Asia, not only affords scope for variety in plant-life, but also in animal nature. The number of species of animate creatures peculiar to it amounts to nearly one-fifth of the whole world. Ruminants largely prevail, and what are known as the domestic animals attain a higher perfection in Asia than elsewhere. Of the deer tribe more than one-half belong specially to it, though less than a fifth of the species of antelopes show themselves in its area. Four distinct varieties of ox are domesticated in different districts. The elephant, the horse, the ass, the camel, and the dromedary are valued adjuncts of life there. The hog is abhorred by Buddhists and Mohammedans, and is mainly domesticated in China. The dog is used not only for sport but for food. The true apes, except the chimpanzee, belong to Asia. Four kinds of bears, besides the commoner sorts, have their habitat in it; so have three different species of the rhinoceros. Rodents are very numerous, and several species of musks—the smallest of hoofed animals—and particularly the perfume-producing musk of Tibet, inhabit its forests. The birds of Asia are not very peculiar, unless it be for the great variety and brilliant colours of its gallinaceous fowls. Of reptiles, fishes, and insects there are not so many special varieties as might at first sight have been expected. So that, on the whole, these portions of Asiatic zoology require only general mention.

Mineralogy.—Asia is rich in minerals. Copper, iron, and lead were in olden times worked in the mountains of Kurdistan; gold, copper, and iron are found in the Ural Mountains and in the Altai chain; India yields gold and coal; Burma, petroleum and rubies. China, Tibet, and Japan furnish quicksilver; the island of Banca, tin. Zinc, porcelain clay, and coal abound in China. Bokhara yields *lapis luzuli;* Ceylon, sapphires; and Siberia, topazes. In fact, a larger amount of costly jewels and precious stones have been furnished by Asia than by all the other portions of the globe.

THE FRENCH LANGUAGE.—CHAPTER IX.

In the last chapter we explained that each French verb consists of two parts, the first being the *root*, which is mostly invariable, and the second the *termination*, which changes to indicate the different moods, tenses, numbers, and persons of the verb. In "conjugating" a verb all these changes are written or pronounced in a regular order. French regular verbs may best be arranged in four groups, each of which has special terminations of its own for certain cases, as was explained at the end of last lesson; we thus say that in French there are *four* conjugations.

The first conjugation contains more than nine-tenths of all the verbs in the language. The third conjugation, on the other hand, contains very few verbs indeed, as the great majority of verbs ending in *-oir* are regarded as irregular.

The minute formal rules usually given for the formation of the various tenses often only tend to confuse the learner. The following less formal remarks may be found more useful if the student assures himself by personal observation of their accuracy. They will be found applicable to the irregular verbs as well as to the regular:—

The *participle present* always terminates in *ant*.

The *first person plural* always ends with an *s*, and the *third person plural* with *nt*.

The *first* and the *second* person plural of the perfect indicative, and the *third* person singular of the imperfect subjunctive, have always a circumflex over the last vowel before the terminations *mes*, *tes*, *t*, which are in every verb the same.

The *present subjunctive* has the following terminations, viz. *e*, *es*, *e*, *ions*, *iez*, *ent*, in all verbs, except *avoir*, to have, and *être*, to be.

The *imperfect subjunctive* has always the following terminations: *sse*, *sses*, *t*, *ssions*, *ssiez*, *ssent*.

The *second* person singular and the *first* and the *second* person plural of the *imperative* are usually the same as the first person singular and the first and second person plural of the present indicative, the pronouns of the latter being left out. The exceptions to this rule occur in the verbs *avoir*, to have, and *être*, to be.

The *imperfect indicative*, the *conditional*, and the *future* have the following terminations, without a single exception:—Imperfect, *ais*, *ais*, *ait*, *ions*, *iez*, *aient;* conditional, *rais*, *rais*, *rait*. *rions*, *riez*, *raient;* future, *rai*, *ras*, *ra*, *rons*, *rez*, *ront*. It will be noticed that the terminations of the imperfect and those of the conditional are the same, with the exception of the letter *r*. The imperfect may also sometimes seem to have an *r* before *ais*, but then on investigation it will be seen that *r* belongs to the root-stem of the verb, and not to its *termination*.

The following plain rules for the formation of the persons of verbs may be found useful, especially if the student examines the paradigms and verifies by his own observation their accuracy and pertinence:—

If the *first* person ends in *e* mute, the *second* ends in *es*, and the *third* is the same as the first—except in the imperfect subjunctive, the third person singular of which always

ends in *t* with a circumflex over the preceding vowel; as *Je parle, tu parles, il parle; que je parlasse, que tu parlasses, qu'il parlât.*

If the *first* person ends in *s* or *x*, the *second* is the same as the first, and the *third* takes *t* in place of the *s* or *x*. But if a consonant precedes the *s*, as when the first person ends in *ds*, *cs*, or *ts*, the *s* is suppressed in the third person, without the *t* being substituted for it; as *Je parlais, tu parlais, il parlait; je veux, tu veux, il veut; je vends, tu vends, il vend; je vaincs, tu vaincs, il vainc; je mets, tu mets, il met.*

When the *first* person ends in *ai*, the *second* ends in *as* and the *third* in *a*; as *Je parlai, tu parlas, il parla*; *j'ai, tu as, il a.*

The *first* and *second* persons plural end in *ons* and *ez* in every tense except the perfect of the indicative, in which tense they always end in *mes, tes;* except *nous sommes, vous êtes, vous faites, vous dites*, in the present tenses of *être, faire*, and *dire*.

The *third* person plural ends in *ent* in every tense except the future, in which it ends always in *ont;* except in *ils ont, ils sont, ils font, ils vont*, which are the third persons plural of *avoir, être, faire*, and *aller*.

The present indicative, *je parle*, is used to translate I speak, I am speaking, I do speak; the present conditional, *je parlerais*, means I should or would speak; the present subjunctive, *que je parle*, means (it is possible) that I may speak, or that I shall speak, thus being used in a future sense.

In all cases where in English the verb "to do" is used—thus, I do speak, I did speak—it is simply ignored in translating into French; as, I do speak, *je parle:* I did speak, *je parlai.*

The student may now proceed to learn the first conjugation, and after he has done this he should carefully re-read the preceding part of this lesson, and also the whole of last lesson. When he has done so, anything which seemed difficult or obscure to him should appear quite plain.

Learn the simple tenses first. The compound ones should present little difficulty, as they closely resemble those of the auxiliary verbs.

First Conjugation—PARLER, to speak.

Pres. infinitive,	Parler,	*to speak.*
Past infinitive,	Avoir parlé,	*to have spoken.*
Pres. participle,	Parlant,	*speaking.*
Past participle,	Ayant parlé,	*having spoken.*

INDICATIVE MOOD.

PRESENT TENSE.

Sing. 1.	Je parle,	*I speak.*
2.	tu parles,	*thou speakest.*
3.	il parle,	*he speaks.*
Plur. 1.	nous parlons,	*we speak.*
2.	vous parlez,	*you speak.*
3.	ils parlent,	*they speak.*

IMPERFECT TENSE.

Sing. 1.	Je parlais,	*I was speaking.*
2.	tu parlais,	*thou wast speaking.*
3.	il parlait,	*he was speaking.*
Plur. 1.	nous parlions,	*we were speaking.*
2.	vous parliez,	*you were speaking.*
3.	ils parlaient,	*they were speaking.*

PERFECT DEFINITE TENSE.

Sing. 1.	Je parlai,	*I spoke.*
2.	tu parlas,	*thou spokest.*
3.	il parla,	*he spoke.*
Plur. 1.	nous parlâmes,	*we spoke.*
2.	vous parlâtes,	*you spoke.*
3.	ils parlèrent,	*they spoke.*

PERFECT INDEFINITE TENSE.

Sing. 1.	J'ai parlé,	*I have spoken.*
2.	tu as parlé,	*thou hast spoken.*
3.	il a parlé,	*he has spoken.*
Plur. 1.	nous avons parlé,	*we have spoken.*
2.	vous avez parlé,	*you have spoken.*
3.	ils ont parlé,	*they have spoken.*

PLUPERFECT TENSE.

Sing. 1.	J'eus parlé,	*I had spoken.*
2.	tu eus parlé,	*thou hadst spoken.*
3.	il eut parlé,	*he had spoken.*
Plur. 1.	nous eûmes parlé,	*we had spoken.*
2.	vous eûtes parlé,	*you had spoken.*
3.	ils eurent parlé,	*they had spoken.*

PLUPERFECT DEFINITE TENSE.

Sing. 1.	J'avais parlé,	*I had spoken.*
2.	tu avais parlé,	*thou hadst spoken.*
3.	il avait parlé,	*he had spoken.*
Plur. 1.	nous avions parlé,	*we had spoken.*
2.	vous aviez parlé,	*you had spoken.*
3.	ils avaient parlé,	*they had spoken.*

FUTURE TENSE.

Sing. 1.	Je parlerai,	*I shall speak.*
2.	tu parleras,	*thou wilt speak.*
3.	il parlera,	*he will speak.*
Plur. 1.	nous parlerons,	*we shall speak.*
2.	vous parlerez,	*you will speak.*
3.	ils parleront,	*they will speak.*

FUTURE PERFECT TENSE.

Sing. 1.	J'aurai parlé,	*I shall have spoken.*
2.	tu auras parlé,	*thou wilt have spoken.*
3.	il aura parlé,	*he will have spoken.*
Plur. 1.	nous aurons parlé,	*we shall have spoken.*
2.	vous aurez parlé,	*you will have spoken.*
3.	ils auront parlé,	*they will have spoken.*

CONDITIONAL MOOD.

PRESENT TENSE.

Sing. 1.	Je parlerais,	*I should speak.*
2.	tu parlerais,	*thou wouldst speak.*
3.	il parlerait,	*he would speak.*
Plur. 1.	nous parlerions,	*we should speak.*
2.	vous parleriez,	*you would speak.*
3.	ils parleraient,	*they would speak.*

PAST TENSE.

Sing. 1.	J'aurais parlé,	*I should have spoken.*
2.	tu aurais parlé,	*thou wouldst have spoken.*
3.	il aurait parlé,	*he would have spoken.*
Plur. 1.	nous aurions parlé,	*we should have spoken.*
2.	vous auriez parlé,	*you would have spoken.*
3.	ils auraient parlé,	*they would have spoken.*

IMPERATIVE MOOD.

Sing. 2.	Parle,	*speak! (thou).*
3.	qu'il parle,	*let him speak.*
Plur. 1.	parlons,	*let us speak.*
2.	parlez,	*speak! (you).*
3.	qu'ils parlent,	*let them speak.*

SUBJUNCTIVE MOOD.

PRESENT TENSE.

Sing. 1.	Que je parle,	*that I may speak.*
2.	que tu parles,	*that thou mayst speak.*
3.	qu'il parle,	*that he may speak.*
Plur. 1.	que nous parlions,	*that we may speak.*
2.	que vous parliez,	*that you may speak.*
3.	qu'ils parlent,	*that they may speak.*

IMPERFECT TENSE.

Sing. 1.	Que je parlasse,	*that I might speak.*
2.	que tu parlasses,	*that thou mightst speak.*
3.	qu'il parlât,	*that he might speak.*
Plur. 1.	que nous parlassions,	*that we might speak.*
2.	que vous parlassiez,	*that you might speak.*
3.	qu'ils parlassent,	*that they might speak.*

PERFECT TENSE.

Sing. 1.	Que j'aie parlé,	*that I may have spoken.*
2.	que tu aies parlé,	*that thou mayst have spoken.*
3.	qu'il ait parlé,	*that he may have spoken.*
Plur. 1.	que nous ayons parlé,	*that we may have spoken.*
2.	que vous ayez parlé,	*that you may have spoken.*
3.	qu'ils aient parlé,	*that they may have spoken.*

PLUPERFECT TENSE.

Sing. 1.	Que j'eusse parlé,	*that I might have spoken.*
2.	que tu eusses parlé,	*that thou mightst have spoken.*
3.	qu'il eût parlé,	*that he might have spoken.*
Plur. 1.	que nous eussions parlé,	*that we might have spoken.*
2.	que vous eussiez parlé,	*that you might have spoken.*
3.	qu'ils eussent parlé,	*that they might have spoken.*

EXERCISES.

Write out in a column a translation of the following sentences, and compare it with the verb as given above. Then mark off and correct all errors:—

Speaking. Having spoken. We speak. He was speaking. They spoke. We have spoken. I had spoken (pluperfect). He had spoken (pluperfect definite). You will speak. They will have spoken. I should speak. He would speak. We would have spoken. Speak (you). That he may speak. That they may speak. That you might speak. That I may have spoken. That you might have spoken.

The following are among the many verbs conjugated like *parler:—Dans-er*, to dance; *port-er*, to carry; *chant-er*, to sing: the root is separated from the termination by a hyphen. For practice conjugate all the simple tenses of each of these verbs, thus—*je pense*, *tu penses*, &c.; *je pensais*, *tu pensais*, &c.

We shall now proceed at once with the remaining three conjugations, for it will afterwards prove useful to have them all together for reference; but the student should make himself thoroughly acquainted with the inflexions of *parler* before leaving the consideration of it.

SECOND CONJUGATION.—The majority of the verbs of the second conjugation have the following characteristic terminations:—Infinitive present, *-ir;* present participle, *-issant;* past participle, *-i;* present indicative, *-is*, *-is*, *-it*, *-issons*, *-issez*, *-issent;* perfect definite, *-is*, *-is*, *-it*, *-îmes*, *-îtes*, *-irent.* The compound tenses are formed in exactly the same way as those of *parler.*

Second Conjugation—FINIR, to finish.

Pres. infinitive,	Finir,	*to finish.*
Past infinitive,	Avoir fini,	*to have finished.*
Pres. participle,	Finissant,	*finishing.*
Past participle.	Ayant fini,	*having finished.*

INDICATIVE MOOD.

PRESENT TENSE.

Sing. 1.	Je finis,	*I finish.*
2.	tu finis,	*thou finishest.*
3.	il finit,	*he finishes.*
Plur. 1.	nous finissons,	*we finish.*
2.	vous finissez,	*you finish.*
3.	ils finissent,	*they finish.*

IMPERFECT TENSE.

Sing. 1.	Je finissais,	*I was finishing.*
2.	tu finissais,	*thou wast finishing.*
3.	il finissait,	*he was finishing.*
Plur. 1.	nous finissions,	*we were finishing.*
2.	vous finissiez,	*you were finishing.*
3.	ils finissaient,	*they were finishing.*

PERFECT DEFINITE TENSE.

Sing. 1.	Je finis,	*I finished.*
2.	tu finis,	*thou finishest.*
3.	il finit,	*he finished.*
Plur. 1.	nous finîmes,	*we finished.*
2.	vous finîtes,	*you finished.*
3.	ils finirent,	*they finished.*

PERFECT INDEFINITE TENSE.

Sing. 1.	J'ai fini,	*I have finished.*
2.	tu as fini,	*thou hast finished.*
3.	il a fini,	*he has finished.*
Plur. 1.	nous avons fini,	*we have finished.*
2.	vous avez fini,	*you have finished.*
3.	ils ont fini,	*they have finished.*

PLUPERFECT TENSE.

Sing. 1.	J'eus fini,	*I had finished.*
2.	tu eus fini,	*thou hadst finished.*
3.	il eut fini,	*he had finished.*
Plur. 1.	nous eûmes fini,	*we had finished.*
2.	vous eûtes fini,	*you had finished.*
3.	ils eurent fini,	*they had finished.*

PLUPERFECT DEFINITE TENSE.

Sing. 1.	J'avais fini,	*I had finished.*
2.	tu avais fini,	*thou hadst finished.*
3.	il avait fini,	*he had finished.*
Plur. 1.	nous avions fini,	*we had finished.*
2.	vous aviez fini,	*you had finished.*
3.	ils avaient fini,	*they had finished*

FUTURE TENSE.

Sing. 1.	Je finirai,	*I shall finish.*
2.	tu finiras,	*thou wilt finish.*
3.	il finira,	*he will finish.*
Plur. 1.	nous finirons,	*we shall finish.*
2.	vous finirez,	*you will finish.*
3.	ils finiront,	*they will finish.*

FUTURE PERFECT TENSE.

Sing. 1.	J'aurai fini,	*I shall have finished.*
2.	tu auras fini,	*thou wilt have finished.*
3.	il aura fini,	*he will have finished.*
Plur. 1.	nous aurons fini,	*we shall have finished.*
2.	vous aurez fini,	*you will have finished.*
3.	ils auront fini,	*they will have finished.*

CONDITIONAL MOOD.

PRESENT TENSE.

Sing. 1.	Je finirais,	*I should finish.*
2.	tu finirais,	*thou wouldst finish.*
3.	il finirait,	*he would finish.*
Plur. 1.	nous finirions,	*we should finish.*
2.	vous finiriez,	*you would finish.*
3.	ils finiraient,	*they would finish.*

PAST TENSE.

Sing. 1.	J'aurais fini,	*I should have finished.*
2.	tu aurais fini,	*thou wouldst have finished.*
3.	il aurait fini,	*he would have finished.*
Plur. 1.	nous aurions fini,	*we should have finished.*
2.	vous auriez fini,	*you would have finished.*
3.	ils auraient fini,	*they would have finished.*

IMPERATIVE MOOD.

Sing. 2.	Finis,	*finish (thou).*
3.	qu'il finisse,	*let him finish.*
Plur. 1.	finissons,	*let us finish.*
2.	finissez,	*finish (you).*
3.	qu'ils finissent,	*let them finish.*

SUBJUNCTIVE MOOD.

PRESENT TENSE.

Sing. 1.	Que je finisse,	*that I may finish.*
2.	que tu finisses,	*that thou mayst finish.*
3.	qu'il finisse,	*that he may finish.*
Plur. 1.	que nous finissions,	*that we may finish.*
2.	que vous finissiez,	*that you may finish.*
3.	qu'ils finissent,	*that they may finish.*

IMPERFECT TENSE.

Sing. 1.	Que je finisse,	*that I might finish.*
2.	que tu finisses,	*that thou mightst finish.*
3.	qu'il finît,	*that he might finish.*
Plur. 1.	que nous finissions,	*that we might finish.*
2.	que vous finissiez,	*that you might finish.*
3.	qu'ils finissent,	*that they might finish.*

PERFECT TENSE.

Sing. 1.	Que j'aie fini,	*that I may have finished.*
2.	que tu aies fini,	*that thou mayst have finished.*
3.	qu'il ait fini,	*that he may have finished.*
Plur. 1.	que nous ayons fini,	*that we may have finished.*
2.	que vous ayez fini,	*that you may have finished.*
3.	qu'ils aient fini,	*that they may have finished.*

PLUPERFECT TENSE.

Sing. 1.	Que j'eusse fini,	*that I might have finished.*
2.	que tu eusses fini,	*that thou mightst have finished.*
3.	qu'il eût fini,	*that he might have finished.*
Plur. 1.	que nous eussions fini,	*that we might have finished.*
2.	que vous eussiez fini,	*that you might have finished.*
3.	qu'ils eussent fini,	*that they might have finished.*

There are three classes of exceptions to the way in which *finir* is conjugated, but the verbs in which they occur are still said to belong to the second conjugation: in all of them the present participle ends in *-ant*, not in [*iss*]*ant*.

Exceptions.—(1) *Dormir*, to sleep; *mentir*, to speak falsely, to lie; *partir*, to start; *sentir*, to feel; *sortir*, to go out; *servir*, to serve; and all their compounds are conjugated thus:—

Dormir, *to sleep;* dormant, *sleeping;* dormi, *slept.*

Indicative.

Present.—Je dors, tu dors, il dort; nous dormons, vous dormez, ils dorment.

Imperfect.—Je dormais, tu dormais, il dormait; nous dormions, vous dormiez, ils dormaient.

Perfect Definite.—Je dormis, tu dormis, il dormit; nous dormîmes, vous dormîtes, ils dormirent.

Future.—Je dormirai, tu dormiras, il dormira; nous dormirons, vous dormirez, ils dormiront.

Conditional.

Present.—Je dormirais, tu dormirais, il dormirait; nous dormirions, vous dormiriez, ils dormiraient.

Subjunctive.

Present.—Que je dorme, que tu dormes, qu'il dorme; que nous dormions, que vous dormiez, qu'ils dorment.

Imperfect.—Que je dormisse, que tu dormisses, qu'il dormît; que nous dormissions, que vous dormissiez, qu'ils dormissent.

Imperative.

Dors, *sleep* (*thou*); dormons, *let us sleep;* dormez, *sleep* (*ye*).

(2) *Ouvrir*, to open; *couvrir*, to cover; *offrir*, to offer; *souffrir*, to suffer; and their compounds are conjugated thus:—

Couvrir, *to cover;* couvrant, *covering;* couvert, *covered.*

Indicative.

Present.—Je couvre, tu couvres, il couvre; nous couvrons, vous couvrez, ils couvrent.

Imperfect.—Je couvrais, tu couvrais, il couvrait; nous couvrions, vous couvriez, ils couvraient.

Perfect Definite.—Je couvris, tu couvris, il couvrit; nous couvrîmes, vous couvrîtes, ils couvrirent.

Future.—Je couvrirai, tu couvriras, il couvrira; nous couvrirons, vous couvrirez, ils couvriront.

Conditional.

Present.—Je couvrirais, tu couvrirais, il couvrirait; nous couvririons, vous couvririez, ils couvriraient.

Subjunctive.

Present.—Que je couvre, que tu couvres, qu'il couvre; que nous couvrions, que vous couvriez, qu'ils couvrent.

Imperfect.—Que je couvrisse, que tu couvrisses, qu'il couvrît; que nous couvrissions, que vous couvrissiez, qu'ils couvrissent.

Imperative.

Couvre, *cover* (*thou*); couvrons, *let us cover;* couvrez, *cover* (*ye*).

(3) *Venir*, to come; *tenir*, to hold; and all compounds of these verbs, such as *revenir*, to return; *contenir*, to contain, are conjugated thus:—

Venir, *to come;* venant, *coming;* venu, *come.*

Indicative.

Present.—Je viens, tu viens, il vient; nous venons, vous venez, ils viennent.

Imperfect.—Je venais, tu venais, il venait; nous venions, vous veniez, ils venaient.

Perfect Definite.—Je vins, tu vins, il vint; nous vînmes, vous vîntes, ils vinrent.

Future.—Je viendrai, tu viendras, il viendra; nous viendrons, vous viendrez, ils viendront.

Conditional.

Present.—Je viendrais tu viendrais, il viendrait; nous viendrions, vous viendriez, ils viendraient.

Subjunctive.

Present.—Que je vienne, que tu viennes, qu'il vienne; que nous venions, que vous veniez, qu'ils viennent.

Imperfect.—Que je vinsse, que tu vinsses, qu'il vînt; que nous vinssions, que vous vinssiez, qu'ils vinssent.

Imperative.

Viens, *come;* venons, *let us come;* venez, *come* (*ye*).

EXERCISES.

Write out in a column a translation of the following sentences, then compare it with the foregoing verb, and mark and correct any error made:—

Finishing. Having finished. We finish. He was finishing. They finished. We have finished. I had finished (pluperfect). He had finished (pluperfect definite). You will finish. They will have finished. I should finish. He would finish. We would have finished. Finish (you). That he may finish. That they may finish. That you might finish. That I may have finished. That you might have finished.

Also conjugate aloud all the moods and tenses of the following verbs:—*Avert-ir*, to warn; *bât-ir*, to build; *fleur-ir*, to blossom; and among the exceptions conjugate (1) *sent-ir*, to feel; *serv-ir*, to serve; *consent-ir*, to consent; (2) *offr-ir*, to offer; *rouvr-ir*, to re-open; (3) *ten-ir*, to hold; *reven-ir*, to return—observing, in doing so, that the terminations given above are added to the root, which is here the part preceding the hyphen.

Third Conjugation.—There are only seven regular verbs in the third conjugation, and they all end in *-evoir;* the most commonly used are *recevoir*, to receive, and *devoir*, to owe. All verbs merely ending in *-oir* have some irregularity, which will require to be learned afterwards. A *c* before an *e* is always sounded like *s*, and a cedilla (*ç*) is placed under the *c* which precedes the termination in these verbs whenever it comes before *a*, *o*, or *u*, so as to make it always sound like *s*. Thus pronounce recevoir, *rĕ-sĕ-vwŏr;* reçu, *rĕ-soo;* reçoivent, *re-swŏv.*

Third Conjugation—Recevoir, to receive.

Pres. infinitive,	Recevoir,	*to receive.*
Past infinitive,	Avoir reçu,	*to have received.*
Pres. participle,	Recevant,	*receiving.*
Past participle,	Ayant reçu,	*having received.*

INDICATIVE MOOD.

PRESENT TENSE.

Sing. 1.	Je reçois,	*I receive.*
2.	tu reçois,	*thou receivest.*
3.	il reçoit,	*he receives.*
Plur. 1.	nous recevons,	*we receive.*
2.	vous recevez,	*you receive.*
3.	ils reçoivent,	*they receive.*

IMPERFECT TENSE.

Sing. 1.	Je recevais,	*I was receiving.*
2.	tu recevais,	*thou wast receiving.*
3.	il recevait,	*he was receiving.*
Plur. 1.	nous recevions,	*we were receiving.*
2.	vous receviez,	*you were receiving.*
3.	ils recevaient,	*they were receiving.*

PERFECT DEFINITE TENSE.

Sing. 1.	Je reçus,	*I received.*
2.	tu reçus,	*thou receivedst.*
3.	il reçut,	*he received.*
Plur. 1.	nous reçûmes,	*we received.*
2.	vous reçûtes,	*you received.*
3.	ils reçurent,	*they received.*

PERFECT INDEFINITE TENSE.

Sing. 1.	J'ai reçu,	*I have received.*
2.	tu as reçu,	*thou hast received.*
3.	il a reçu,	*he has received.*
Plur. 1.	nous avons reçu,	*we have received.*
2.	vous avez reçu,	*you have received.*
3.	ils ont reçu,	*they have received.*

PLUPERFECT TENSE.

Sing. 1.	J'eus reçu,	*I had received.*
2.	tu eus reçu,	*thou hadst received.*
3.	il eut reçu,	*he had received.*
Plur. 1.	nous eûmes reçu,	*we had received.*
2.	vous eûtes reçu,	*you had received.*
3.	ils eurent reçu,	*they had received.*

PLUPERFECT DEFINITE TENSE.

Sing. 1.	J'avais reçu,	*I had received.*
2.	tu avais reçu,	*thou hadst received.*
3.	il avait reçu,	*he had received.*
Plur. 1.	nous avions reçu,	*we had received.*
2.	vous aviez reçu,	*you had received.*
3.	ils avaient reçu,	*they had received.*

FUTURE TENSE.

Sing. 1.	Je recevrai,	*I shall receive.*
2.	tu recevras,	*thou wilt receive.*
3.	il recevra,	*he will receive.*
Plur. 1.	nous recevrons,	*we shall receive.*
2.	vous recevrez,	*you will receive.*
3.	ils recevront,	*they will receive.*

FUTURE PERFECT TENSE.

Sing. 1.	J'aurai reçu,	*I shall have received.*
2.	tu auras reçu,	*thou wilt have received.*
3.	il aura reçu,	*he will have received.*
Plur. 1.	nous aurons reçu,	*we shall have received.*
2.	vous aurez reçu,	*you will have received.*
3.	ils auront reçu,	*they will have received.*

CONDITIONAL MOOD.

PRESENT TENSE.

Sing. 1.	Je recevrais,	*I should receive.*
2.	tu recevrais,	*thou wouldst receive.*
3.	il recevrait,	*he would receive.*
Plur. 1.	nous recevrions,	*we should receive.*
2.	vous recevriez,	*you would receive.*
3.	ils recevraient,	*they would receive.*

PAST TENSE.

Sing. 1.	J'aurais reçu,	*I should have received.*
2.	tu aurais reçu,	*thou wouldst have received.*
3.	il aurait reçu,	*he would have received.*
Plur. 1.	nous aurions reçu,	*we should have received.*
2.	vous auriez reçu,	*you would have received.*
3.	ils auraient reçu,	*they would have received.*

IMPERATIVE MOOD.

Sing. 2.	Reçois,	*receive (thou).*
3.	qu'il reçoive,	*let him receive.*
Plur. 1.	recevons,	*let us receive.*
2.	recevez,	*receive (you).*
3.	qu'ils reçoivent,	*let them receive.*

SUBJUNCTIVE MOOD.

PRESENT TENSE.

Sing. 1.	Que je reçoive,	*that I may receive.*
2.	que tu reçoives,	*that thou mayst receive.*
3.	qu'il reçoive,	*that he may receive.*
Plur. 1.	que nous recevions,	*that we may receive.*
2.	que vous receviez,	*that you may receive.*
3.	qu'ils reçoivent,	*that they may receive.*

IMPERFECT TENSE.

Sing. 1.	Que je reçusse,	*that I might receive.*
2.	que tu reçusses,	*that thou mightst receive.*
3.	qu'il reçût,	*that he might receive.*
Plur. 1.	que nous reçussions,	*that we might receive.*
2.	que vous reçussiez,	*that you might receive.*
3.	qu'ils reçussent,	*that they might receive.*

PERFECT TENSE.

Sing. 1.	Que j'aie reçu,	*that I may have received.*
2.	que tu aies reçu,	*that thou mayst have received*
3.	qu'il ait reçu,	*that he may have received.*
Plur. 1.	que nous ayons reçu,	*that we may have received.*
2.	que vous ayez reçu,	*that you may have received.*
3.	qu'ils aient reçu,	*that they may have received.*

PLUPERFECT TENSE.

Sing. 1.	Que j'eusse reçu,	*that I might have received.*
2.	que tu eusses reçu,	*that thou mightst have received.*
3.	qu'il eût reçu,	*that he might have received.*
Plur. 1.	que nous eussions reçu,	*that we might have received.*
2.	que vous eussiez reçu,	*that you might have received.*
3.	qu'ils eussent reçu,	*that they might have received.*

EXERCISES.

Write out in a column a translation into French of the following sentences, and compare the exercises with the foregoing verb. Then mark off and correct all errors:—

Receiving. Having received. We receive. He was receiving. They received. We have received. I had received (pluperfect). He had received (pluperfect definite). You will receive. They will have received. I should receive. He would receive. We would have received. Receive (you). That he may receive. That they may receive. That you might receive. That I may have received. That you might have received.

FOURTH CONJUGATION.—There are only about forty regular verbs in this conjugation, and they may be recognized by their ending in *-andre*, *-endre*, *-ondre*, *-erdre*, *-ordre* (except *prendre*, to take, and its compounds). The present participle of all regular verbs of this conjugation end in *-dant.*

Fourth Conjugation—VENDRE, to sell.

Pres. infinitive,	Vendre,	*to sell.*
Past infinitive,	Avoir vendu,	*to have sold.*
Pres. participle,	Vendant,	*selling.*
Past participle,	Ayant vendu,	*having sold.*

INDICATIVE MOOD.

PRESENT TENSE.

Sing. 1.	Je vends,	*I sell.*
2.	tu vends,	*thou sellest.*
3.	il vend,	*he sells.*
Plur. 1.	nous vendons,	*we sell.*
2.	vous vendez,	*you sell.*
3.	ils vendent,	*they sell.*

IMPERFECT TENSE.

Sing. 1.	Je vendais,	*I was selling.*
2.	tu vendais,	*thou wast selling.*
3.	il vendait,	*he was selling.*
Plur. 1.	nous vendions,	*we were selling.*
2.	vous vendiez,	*you were selling.*
3.	ils vendaient,	*they were selling.*

PERFECT DEFINITE TENSE.

Sing. 1.	Je vendis,	*I sold.*
2.	tu vendis,	*thou soldst.*
3.	il vendit,	*he sold.*
Plur. 1.	nous vendîmes,	*we sold.*
2.	vous vendîtes,	*you sold.*
3.	ils vendirent,	*they sold.*

PERFECT INDEFINITE TENSE.

Sing. 1.	J'ai vendu,	*I have sold.*
2.	tu as vendu,	*thou hast sold*
3.	il a vendu,	*he has sold.*
Plur. 1.	nous avons vendu,	*we have sold.*
2.	vous avez vendu,	*you have sold.*
3.	ils ont vendu,	*they have sold.*

PLUPERFECT TENSE.

Sing. 1.	J'eus vendu,	*I had sold.*
2.	tu eus vendu,	*thou hadst sold.*
3.	il eut vendu,	*he had sold.*
Plur. 1.	nous eûmes vendu,	*we had sold.*
2.	vous eûtes vendu,	*you had sold.*
3.	ils eurent vendu,	*they had sold.*

PLUPERFECT DEFINITE TENSE.

Sing.	1.	J'avais vendu,	*I had sold.*
	2.	tu avais vendu,	*thou hadst sold.*
	3.	il avait vendu,	*he had sold.*
Plur.	1.	nous avions vendu,	*we had sold.*
	2.	vous aviez vendu,	*you had sold.*
	3.	ils avaient vendu,	*they had sold.*

FUTURE TENSE.

Sing.	1.	Je vendrai,	*I shall sell.*
	2.	tu vendras,	*thou wilt sell.*
	3.	il vendra,	*he will sell.*
Plur.	1.	nous vendrons,	*we shall sell.*
	2.	vous vendrez,	*you will sell.*
	3.	ils vendront,	*they will sell.*

FUTURE PERFECT TENSE.

Sing.	1.	J'aurai vendu,	*I shall have sold.*
	2.	tu auras vendu,	*thou wilt have sold.*
	3.	il aura vendu,	*he will have sold.*
Plur.	1.	nous aurons vendu,	*we shall have sold.*
	2.	vous aurez vendu,	*you will have sold.*
	3.	ils auront vendu,	*they will have sold.*

CONDITIONAL MOOD.

PRESENT TENSE.

Sing.	1.	Je vendrais,	*I should sell.*
	2.	tu vendrais,	*thou wouldst sell.*
	3.	il vendrait,	*he would sell.*
Plur.	1.	nous vendrions,	*we should sell.*
	2.	vous vendriez,	*you would sell.*
	3.	ils vendraient,	*they would sell.*

PAST TENSE.

Sing.	1.	J'aurais vendu,	*I should have sold.*
	2.	tu aurais vendu,	*thou wouldst have sold.*
	3.	il aurait vendu,	*he would have sold.*
Plur.	1.	nous aurions vendu,	*we should have sold.*
	2.	vous auriez vendu,	*you would have sold.*
	3.	ils auraient vendu,	*they would have sold.*

IMPERATIVE MOOD.

Sing.	2.	Vends,	*sell (thou).*
	3.	qu'il vende,	*let him sell.*
Plur.	1.	vendons,	*let us sell.*
	2.	vendez,	*sell (you).*
	3.	qu'ils vendent,	*let them sell.*

SUBJUNCTIVE MOOD.

PRESENT TENSE.

Sing.	1.	Que je vende,	*that I may sell.*
	2.	que tu vendes,	*that thou mayst sell.*
	3.	qu'il vende,	*that he may sell.*
Plur.	1.	que nous vendions,	*that we may sell.*
	2.	que vous vendiez,	*that you may sell.*
	3.	qu'ils vendent,	*that they may sell.*

IMPERFECT TENSE.

Sing.	1.	Que je vendisse,	*that I might sell.*
	2.	que tu vendisses,	*that thou mightst sell.*
	3.	qu'il vendît,	*that he might sell.*
Plur.	1.	que nous vendissions,	*that we might sell.*
	2.	que vous vendissiez,	*that you might sell.*
	3.	qu'ils vendissent,	*that they might sell.*

PERFECT TENSE.

Sing.	1.	Que j'aie vendu,	*that I may have sold.*
	2.	que tu aies vendu,	*that thou mayst have sold.*
	3.	qu'il ait vendu,	*that he may have sold.*
Plur.	1.	que nous ayons vendu,	*that we may have sold.*
	2.	que vous ayez vendu,	*that you may have sold.*
	3.	qu'ils aient vendu,	*that they may have sold.*

PLUPERFECT TENSE.

Sing.	1.	Que j'eusse vendu,	*that I might have sold.*
	2.	que tu eusses vendu,	*that thou mightst have sold.*
	3.	qu'il eût vendu,	*that he might have sold.*
Plur.	1.	que nous eussions vendu,	*that we might have sold.*
	2.	que vous eussiez vendu,	*that you might have sold.*
	3.	qu'ils eussent vendu,	*that they might have sold.*

Many of the irregular verbs belonging to this conjugation may be arranged under the three following heads:—

EXCEPTIONS.—(1) Verbs ending in *-aître* and *-oître*, as *connaître*, to be acquainted with, *croître*, to grow. Note that the *i* of the termination always has a circumflex when it comes before a *t*.

Connaître, *to know;* connaissant, *knowing;* connu, *known.*

INDICATIVE.

Present.—Je connais, tu connais, il connaît; nous connaissons, vous connaissez, ils connaissent.

Imperfect.—Je connaissais, tu connaissais, il connaissait; nous connaissions, vous connaissiez, ils connaissaient.

Perfect Definite.—Je connus, tu connus, il connut; nous connûmes, vous connûtes, ils connurent.

Future.—Je connaîtrai, tu connaîtras, il connaîtra; nous connaîtrons, vous connaîtrez, ils connaîtront.

CONDITIONAL.

Present.—Je connaîtrais, tu connaîtrais, il connaîtrait; nous connaîtrions, vous connaîtriez, ils connaîtraient.

SUBJUNCTIVE.

Present.—Que je connaisse, que tu connaisses, qu'il connaisse; que nous connaissions, que vous connaissiez, qu'ils connaissent.

Imperfect.—Que je connusse, que tu connusses, qu'il connût; que nous connussions, que vous connussiez, qu'ils connussent.

IMPERATIVE.

Connais, *know (thou);* connaissons, *let us know;* connaissez, *know (ye).*

(2) Verbs ending in *-uire*, as *conduire*, to lead, *reluire*, to shine.

Conduire, *to lead;* conduisant, *leading;* conduit, *led.*

INDICATIVE.

Present.—Je conduis, tu conduis, il conduit; nous conduisons, vous conduisez, ils conduisent.

Imperfect.—Je conduisais, tu conduisais, il conduisait; nous conduisions, vous conduisiez, ils conduisaient.

Perfect Definite.—Je conduisis, tu conduisis, il conduisit; nous conduisîmes, vous conduisîtes, ils conduisirent.

Future.—Je conduirai, tu conduiras, il conduira; nous conduirons, vous conduirez, ils conduiront.

CONDITIONAL.

Present.—Je conduirais, tu conduirais, il conduirait; nous conduirions, vous conduiriez, ils conduiraient.

SUBJUNCTIVE.

Present.—Que je conduise, que tu conduises, qu'il conduise; que nous conduisions, que vous conduisiez, qu'ils conduisent.

Imperfect.—Que je conduisisse, que tu conduisisses, qu'il conduisît; que nous conduisissions, que vous conduisissiez, qu'ils conduisissent.

IMPERATIVE.

Conduis, *lead (thou);* conduisons, *let us lead;* conduisez, *lead (ye).*

(3) Verbs ending in *-aindre*, *-eindre*, *-oindre*, as *craindre*, to fear; *peindre*, to paint; *joindre*, to join.

Craindre, *to fear;* craignant, *fearing;* craint, *feared.*

INDICATIVE.

Present.—Je crains, tu crains, il craint; nous craignons, vous craignez, ils craignent.

Imperfect.—Je craignais, tu craignais, il craignait; nous craignions, vous craigniez, ils craignaient.

Perfect Definite.—Je craignis, tu craignis, il craignit; nous craignîmes, vous craignîtes, ils craignirent.

Future.—Je craindrai, tu craindras, il craindra; nous craindrons, vous craindrez, ils craindront.

CONDITIONAL.

Present.—Je craindrais, tu craindrais, il craindrait; nous craindrions, vous craindriez, ils craindraient.

SUBJUNCTIVE.

Present.—Que je craigne, que tu craignes, qu'il craigne; que nous craignions, que vous craigniez, qu'ils craignent.

Imperfect.—Que je craignisse, que tu craignisses, qu'il craignît; que nous craignissions, que vous craignissiez, qu'ils craignissent.

IMPERATIVE.

Crains, *fear* (*thou*); craignons, *let us fear;* craignez, *fear* (*ye*).

EXERCISES.

Write out in a column a translation into French of the following sentences, then compare each word with the part of the verb corresponding to it; mark off, and correct all errors:—

Selling. Having sold. We sell. He was selling. They sell. We have sold. I had sold (pluperfect). He had sold (pluperfect definite). You will sell. They will have sold. I should sell. He would sell. We should have sold. Sell (you). That he may sell. That they may sell. That you might sell. That I may have sold. That you might have sold.

Write out from memory (1) all the third persons singular of all the verbs conjugated in this and in the preceding chapter; (2) all the third persons plural; (3) the infinitives, the imperatives, and the participles (masculine and feminine). After which diligently compare with the matter given in these chapters, and correct.

Also conjugate aloud all the moods and tenses of the following verbs:—*Prétend-re*, to pretend; *fond-re*, to melt; and among the exceptions conjugate (1) *par-aître*, to appear; *cr-oître*, to grow; (2) *prod-uire*, to produce; *detr-uire*, to destroy; (3) *pl-aindre*, to pity; *att-eindre*, to reach; *j-oindre*, to join.

NATURAL PHILOSOPHY.—CHAPTER XII.
PNEUMATICS.

GASES—THE ATMOSPHERE—COMPOSITION OF AIR—WEIGHT AND PRESSURE OF AIR—PRESSURE OF GASES—ATMOSPHERIC PRESSURE—BAROMETERS—BAROMETRICAL VARIATIONS—WEATHER INDICATIONS—BAROMETRICAL CORRECTIONS—SIPHON—SIPHON-GAUGES—BURDON'S PRESSURE-GAUGE—BOYLE'S LAW—VOLUMETER—MANOMETER—DALTON'S LAW—MIXTURE OF GASES—ABSORPTION OF GASES—DIFFUSION OF GASES—ABSORPTION BY SOLIDS—KINETIC THEORY OF GASES—BALLOONS—PARACHUTE.

THAT branch of hydrodynamics which applies the principles of dynamics to the investigation of the phenomena presented by gaseous bodies under all circumstances of pressure, density, and elasticity, is termed *pneumatics.*

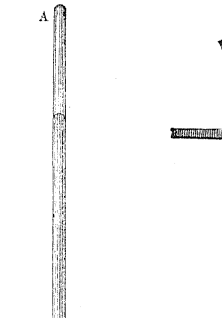
The atmosphere or aërial ocean which envelops the earth is a material body which possesses weight, and exerts a pressure at the earth's surface of 14·7 lbs. per square inch. As this pressure is exerted equally in every direction, and as the solid parts of our bodies contain within them incompressible fluids, while the spaces are filled with air exerting a pressure equal to that of the external air, the outward pressure is balanced and equilibrium maintained, so that the great weight of the air, nearly 16 tons upon the human body, causes no inconvenience. As all gases possess the property of *elasticity*, a tendency which the particles have to recede from one another when free to do so, they are capable of being condensed by pressure, and of again assuming their former volume when the pressure is removed. For this reason the air decreases in density the higher the altitude attained from the earth's surface. At an elevation of about $3\frac{1}{2}$ miles the density of the air is one half of its density at the earth's surface, and at an altitude of 7 miles it will be about one-fourth of this density. It is generally supposed that the height of the atmosphere extends to some 45 miles above sea-level, at which altitude the force of expansion and that of gravity balance each other.

Air is composed of a mixture of oxygen and nitrogen gases, with small and variable proportions of other gases. Its average composition by volume is—

Nitrogen, ...	78·49
Oxygen, ...	20·63
Aqueous Vapour, ...	0·84
Carbonic Acid, ...	0·04
	100·00

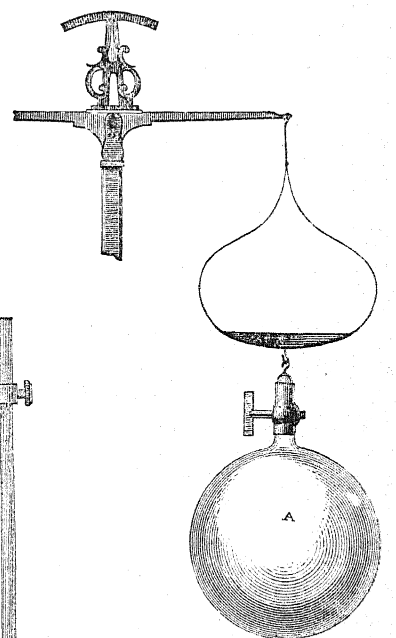
The carbonic acid in the air is given off from the respiration of animals, from the decomposition of organic substances, and from the processes of combustion. This enormous continual production of carbonic acid is, however, compensated by plants in the process of vegetation, which, decomposing the carbonic acid, absorb the carbon, and restore to the atmosphere the oxygen, so that the composition of the atmosphere remains constant. The weight of the air, and its pressure on all bodies on the earth's surface, was unknown before the time of Galileo, and it was not satisfactorily demonstrated till Torricelli filled a glass tube (fig. 1), over 30 inches long, with mercury, and closing the end B with his finger, inserted it into a vessel containing mercury, when it fell in the tube until the top of the column stood about 30 inches from the surface of the mercury in the vessel. It was then at once seen that the maintenance of

Fig. 1.



Torricelli's Experiment.

Fig. 2.



Guericke's Experiment.

the mercury in the tube was the effect of a perfectly defined external cause, while its fluctuations from day to day with the varying condition of the atmosphere strongly corroborated the opinion that it was due to the weight of the external air on the surface of the mercury in the vessel. Otto Guericke, by means of the air-pump, of which he was the inventor, exhausted a glass globe, A, in fig. 2, fitted with a stopcock, of the air it contained; then very carefully weighing the exhausted globe when attached to a delicate scale beam, and as soon as the arm was horizontal opening the stopcock, he found that immediately the air rushed in the globe descended. From this he inferred that the additional weight added to restore the equilibrium of the arm was equal to the weight of the air contained in the globe.

The pressure which gases exert on their own molecules, and on the sides of the containing vessels, may be considered in two ways; when the pressure is withdrawn from a body of gas conceived to be independent of weight, the expansive force will be found to exert itself equally in all directions, both on the vessel containing it, and the mass itself, as the repulsive force between the molecules is the same on all points. When gases are considered as possessing weight, the pressures they produce are subject to the same laws as

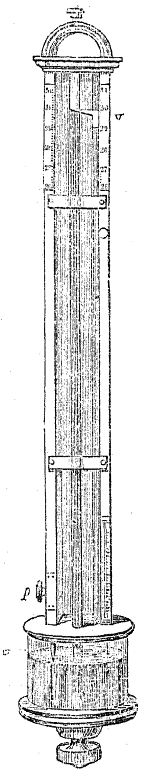
those governing the weights of liquids, and the pressure of a gas increases from the top of a column to the base, and acts on the sides of the vessel and on any small portion of the surface with a pressure equal to the weight of a column of gas whose base is this surface, and whose height is its distance from the base to the top of the column. This pressure is independent of the shape or capacity of the containing vessel so long as the height of the column remains the same. The air may therefore be regarded as a fluid having a certain depth, and exercising the same pressure as that of a liquid of very little density.

From observations made upon the twilight, and the luminosity of meteorites, undoubtedly due to the action of air, seen at an elevation of some 200 miles, it would seem to indicate that in the form of a very attenuated ether the atmosphere must extend to considerable distances beyond what was at first supposed. At present the limit of this rare medium is undetermined. The weight of 100 cubic inches of air being equivalent to 31 grains, the whole pressure exerted upon the earth's surface is enormous. The crushing force of the downward pressure of the air is experimentally illustrated by covering one end of a cylindrical glass vessel with a piece of moistened bladder, and then, placing the other end of the glass upon the plate of an air-pump, exhausting the air from the inside of the tube; on the air being rarefied the bladder collapses and is rent asunder with a loud report, caused by the sudden entrance of the air into the tube. The Magdeburg hemispheres (fig. 1, Plate XI.), invented by Otto Guericke, demonstrate that this pressure acts in all directions; A and B are two hollow metal hemispheres about $4\frac{1}{2}$ inches diameter, the edges of which are made to fit well and closely together, and to form an air-tight joint when greased. A stopcock, E, is attached to the lower one, furnished with a screw, D, for attachment to the air-pump; upon the upper hemisphere, A, is attached a handle. So long as the hemispheres contain air they can be easily detached from one another, the internal air counteracting the external pressure of the atmosphere; but on exhausting the internal air, both hemispheres are drawn together, and cannot be separated without the expenditure of considerable force. And as this cohesion is the same in whatever position they are placed, the pressure of the atmosphere is transmitted in all directions.

As the pressure of the atmosphere on the square inch is equal to 14·7 lbs., the pressure upon a square foot is equal to 2160 lbs., or nearly a ton, which, expressed in the metric system, represents a pressure at 0° C. at the sea-level of 760 millimetres, equivalent to 29·9217 inches, and a pressure on a square centimetre is equal to 1·03296 kilogrammes. When a gas or liquid is exposed to a pressure of 15 lbs. to the square inch, it is represented as a pressure of *one atmosphere;* so that if under a pressure of 75 lbs. of steam, a boiler is said to be under a pressure of five atmospheres.

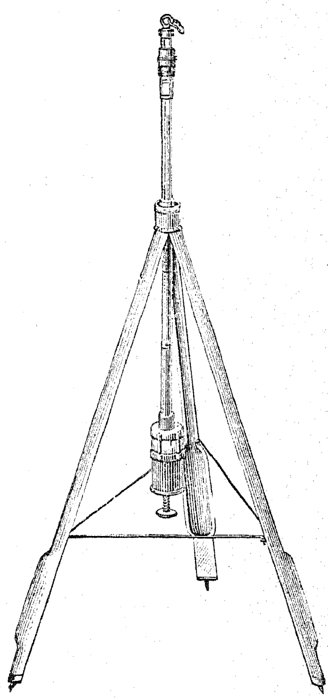
Instruments employed for *measuring the pressure of the atmosphere* are called *barometers*. In its simplest form the barometer consists of a glass tube 33 inches in length, similar to that used in Torricelli's experiment, and containing a column of mercury cleaned by the process of boiling, and supported in the tube by the atmospheric pressure which it serves to measure. The object of boiling is to exclude all traces of air and moisture from the empty space at the top of the tube. The height of the column is the difference in level between the surface of the liquid in the tube and in the cup. The great specific gravity of mercury renders that liquid most suitable for the construction of a barometer, as the height of the column is correspondingly small. The ordinary cistern barometer is shown in fig. 3. The tube containing the column of mercury dips into the cistern below, and both are inclosed in a suitable case to prevent injury. The upper portion of the case carries a scale extending from 26 inches to 31 inches above the level of the mercury in the reservoir, subdivided into tenths of an inch, with a movable index or vernier, V, again subdividing the inch into hundredths, so that the height of the column of mercury can be read off in inches, tenths, and hundredths of an inch. The screw, *p*, is for the purpose of forcing the mercury up to the top of the tube, and securing the fluid in the cup from spilling when the instrument is carried from place to place. A thermometer is generally attached to the case of the barometer on one side of the

Fig. 3.



Cistern Barometer.

Fig. 4.



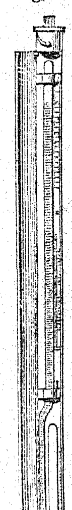
Travelling Cistern Barometer.

tube, to indicate temperature. The barometer requires to be always placed in a perfectly vertical position, otherwise the tube will elongate the column of mercury, and the number read off by the scale will be no true indication of atmospheric pressure. The mean height of the mercury at the level of the sea is 29·92 inches. In a water barometer it would be about 34 feet. The pressure of the atmosphere on a square inch is calculated by comparing the weight of a column of mercury whose base is a square inch and whose height is equal to the height of a column of mercury in the barometer.

Thus, taking the specific gravity of mercury as 13·6, and the weight of a cubic foot of distilled water as 1000 oz., and the height of the mercury in the barometer tube as 30 inches at sea-level, the pressure of the atmosphere on a square inch $= (30 \times 1 \times 1 \times \frac{1000}{1728} \times 13{\cdot}6)$ oz. $= \frac{30 \times 1000 \times 136}{1728 \times 10}$ oz., which will be $236\frac{1}{9}$ oz., or $14\frac{109}{144}$ lbs. Many modifications of the form of the barometer are in use. Some, intended for travelling, are so arranged that the supports shut up like a staff, inclosing the tube, as in fig. 4.

The *siphon* barometer (fig. 5), which is a more convenient form than that of the Torricelli tube, consists of a bent tube in which the two unequal arms are joined together by a capillary tube, so that when the instrument is inverted the longer tube always remains charged with mercury by reason of the capillarity of the small connecting tube, and air cannot enter the longer branch. As the shorter arm is closed there is a capillary aperture in the side through which the atmospheric pressure is

Fig. 5



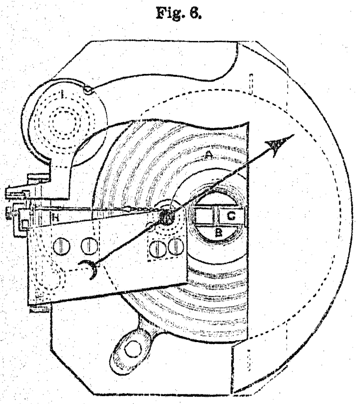
Siphon Barometer in case.

transmitted, but so minute as to prevent any escape of mercury. The difference between the levels of the mercury in the two arms is the height of the barometer. This is determined by means of two scales, one placed at the top of the longer tube and the other at the top of the shorter, and having a common zero about the middle of the longer arm. These scales are graduated in opposite directions, and being both furnished with sliding verniers, the total height of the barometer, which is the sum of the two distances from the zero indicated by the scales, is given in tenths and hundredths of the inch.

The *wheel* barometer is frequently used as a weather glass, but is not sufficiently accurate for scientific measurements, though it indicates with great clearness any change in pressure which is taking place for the time being without showing the exact height of the column of mercury. The instrument consists of a siphon barometer, the short arm of which is open at the top, and in which a float is placed upon the surface of the mercury, and nearly balanced by another weight connected with it by a fine cord, which passes over a pulley carrying an index hand round a graduated dial, on which is marked *stormy*, *rain*, *fair*, *set fair*, &c. The variations in the height of the mercury cause this float to rise and fall, and this motion is transferred to the pulley and index as it turns on its axis.

The *aneroid* barometer (so called from the Greek α, without; νερος, fluid), being constructed without the use of any liquid, is of various forms. One of the simplest consists of a shallow cylindrical metal box A (fig. 6), from which the air has been exhausted. The upper plate of this box is of very thin elastic metal, capable of yielding freely to the slightest variations of pressure of the atmosphere; thus, as the pressure increases, the upper plate is depressed inwards, and with any decrease of pressure it springs back and rises in the opposite direction. This variation in the position of the surface of the upper plate is recorded by means of a combination of delicate multiplying levers, which, acting on an index, indicates the pressure upon a graduated circular scale. The divisions of this scale are determined by reference to the height of the mercurial barometer at various pressures. The chief advantages of the aneroid barometer is portability and its extreme delicacy, which enables it to register the difference in pressure of the smallest elevations; indeed it is so sensitive as to indicate the difference between the ceiling and the floor of a room. It is usually employed in measuring the altitudes of mountains, and the depths of the shafts of mines, wells, &c. The chief cause of error in the aneroid barometer arises from the mechanical transmission of the motion through the series of multiplying levers.

Fig. 6.



Aneroid Barometer.

As most of the barometers in use as weather glasses in Great Britain are constructed in London, their indications are unreliable, except for places of the same level and general climatic conditions as London. A barometer observed at the level of the Thames would register a certain height, but if carried to the top of Primrose Hill, some 400 feet higher, would stand nearly half an inch lower, and in consequence would register weather of a different character; therefore, as the pressure varies with the level and climatic influences, in using the barometer when exact observations are required various corrections have to be made. When the height of the barometer in the same place is observed for several days, it will be found to vary continually, not only from day to day, but also in the same day, and the extent of these variations are different in different places. They increase as the barometer is moved from the equator towards the poles; at the equator the variations are at a minimum, and do not exceed 6 millimetres, in the tropics 30, in France 40, and at 25 degrees from the pole they reach 60 millimetres. These variations are at their maximum in the winter. The *mean daily height* of the barometer is obtained by dividing the sum of the successive hourly observations by 24; the *mean monthly height* is the sum of the mean daily heights divided by 30; and the *mean yearly height* the sum of the mean monthly heights divided by 12. At the equator the value of the mean annual height is 29·84 inches; between latitudes 30 and 40 it increases to 30·04 inches. Owing to the lower temperature in winter, the mean monthly height is greater than in the summer. The variations of the barometer are of two kinds—*accidental* variations, which have no defined regularity of movement, but depend upon the direction of the wind, the season of the year, and geographical position; and *daily* variations, which regularly occur at certain hours of the day. At the equator accidental variations are unobserved, but the daily variations occur with such regularity that the barometer may be regarded as a kind of clock. Between mid-day and four o'clock the mercury is depressed; it then rises, and reaches its maximum about ten o'clock at night, when depression again commences, and reaches its minimum about four o clock in the morning, and a second minimum again at ten o'clock. In the temperate zone, where the daily variations and the accidental variations take place together, the former are more difficult to observe. The hours of the maximum and minimum daily variations are found to be the same in all climates, and to vary very little with the seasons. The variations of the barometer are generally observed to be in the reverse direction of the rise and fall of the thermometer, so that as temperature rises the barometer falls, and as temperature falls the barometer rises. Therefore the barometrical variations at any given place are produced by the expansion or contraction of the air, and therefore consequent upon its change of density. As all atmospheric currents are the result of variations in the temperature of masses of air, if any portion becomes warmer than its surrounding portions, its density is reduced by expansion, and it rises upwards; therefore the pressure is diminished and the barometer falls. Also, if any portion of the atmosphere retains its temperature while the surrounding masses of air become cooler, the barometer falls, as the density of the surrounding air is greater; so that often while the barometer falls in one place it rises in another. The daily variations of the barometer are the result of the expansions and contractions of the atmosphere from solar heat during the diurnal rotation of the earth. In Great Britain the height of the barometer in fine weather averages above 30 inches, and it falls below this height whenever there is rain, wind, or storm, and as a rule, when the barometer stands at 30 inches, the number of fine and wet days are about equal. Ascertained facts such as these have arranged the indications of the state of the weather marked on barometers, counting by thirds of an inch above and below 30 inches.

Height.	Weather.
31 inches,	Very dry.
$30\frac{2}{3}$ "	Settled weather.
$30\frac{1}{3}$ "	Fine weather.
30 "	Changeable.
$29\frac{2}{3}$ "	Rain or wind.
$29\frac{1}{3}$ "	Much Rain.
29 "	Stormy.

The rise and fall of the barometer really only measures the pressure of the atmosphere, and although a change of weather may frequently coincide with a change of pressure, that rather arises from the meteorological peculiarities of this climate. A fall in the barometer usually foretells rain in these latitudes, as the prevailing winds are the south-west and the north-east. The former, coming from the heated equatorial regions, are warmer and lighter, and therefore ascend to the higher regions of the atmosphere where they cool and become denser, and being charged with moisture as they swept over

PNEUMATICS.

Fig. 1.

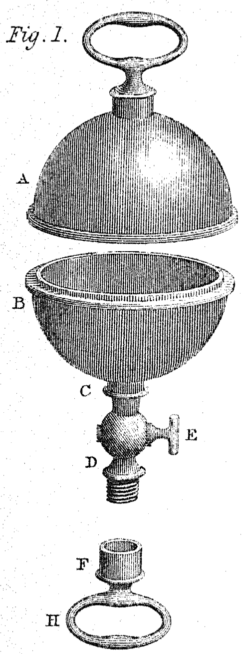


Fig. 2. Fig. 3.

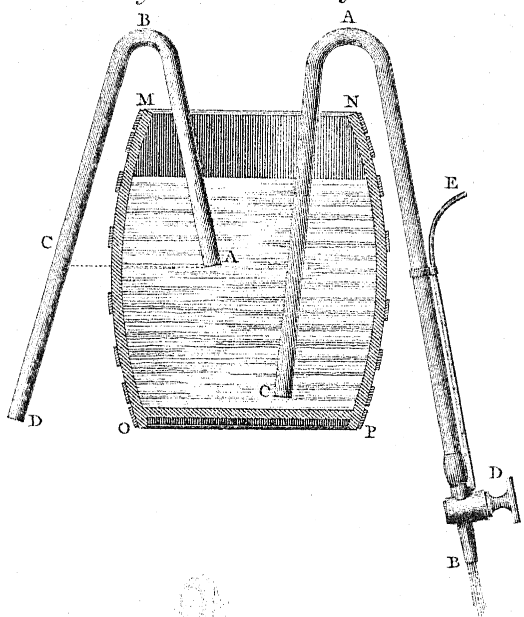


Fig. 4.

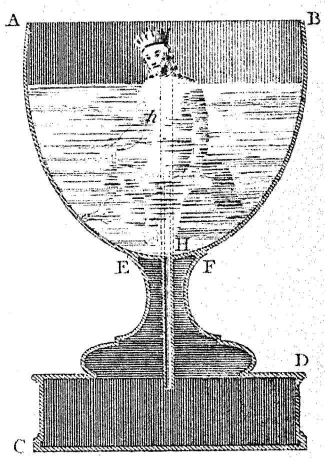


Fig. 6.

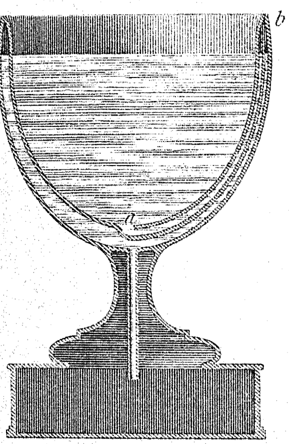


Fig. 5.

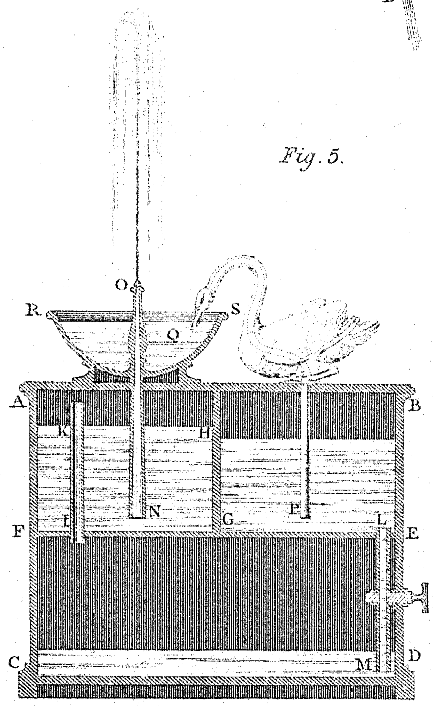


Fig. 9.

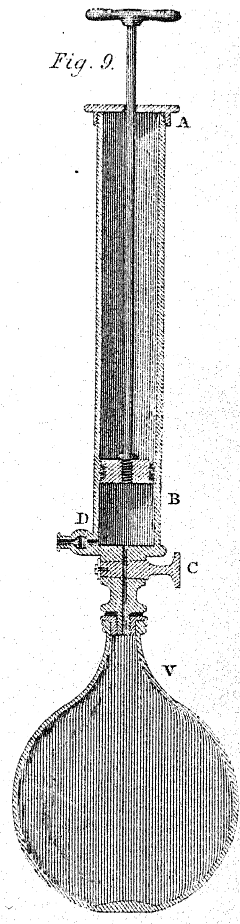


Fig. 7.

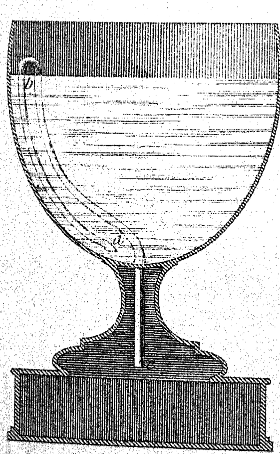
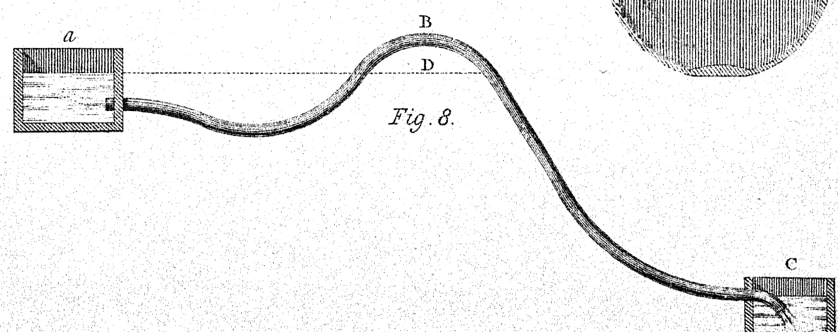


Fig. 8.



the Atlantic Ocean precipitate it in rain. A fall in the barometer is therefore a fair indication of the approach of the south-westerly winds. The north-east winds, on the contrary, reach this country after having traversed large tracts of dry land in Central and Northern Europe; it is therefore dry and more dense, so that the barometer rises. A continuous rise or fall of the barometer for two or three days, either towards fine weather or towards rain, generally indicates the condition of the weather approximately. Any sudden rise or fall of the barometer prognosticates the immediate approach of bad weather and gales of wind.

Mercurial cistern barometers have always a depression on the top of the column of mercury due to *capillarity*, unless the internal diameter of the tube exceeds three quarters of an inch. In consequence of this the barometric reading, as reckoned from the top of the convex meniscus, would indicate a pressure a little less than that of the atmosphere. To make the necessary correction due to this depression, the diameter of the tube and height of the meniscus require to be known. The elevation of the meniscus will vary according as it has been formed during a rising or falling of the mercury. To determine this height the vernier should be brought first to the level with the top of the column of mercury at the base of the depression, and afterwards to the crown of the meniscus. The difference in the two readings gives the height of the meniscus. The internal diameter of the tube and the height of the meniscus being ascertained, the necessary corrections for capillarity will be ascertained from the table:—

Internal Diameter of Tube in inches.	Height of Sagitta of Meniscus in Inches.						
	0·010	0·015	0·020	0·025	0·030	0·035	0·040
0·157	0·0293	0·0431	0·0555	0·0677	0·0780	0·0870	0·0948
0·236	0·0119	0·0176	0·0231	0·0294	0·0342	0·0398	0·0432
0·315	0·0060	0·0088	0·0118	0·0144	0·0175	0·0196	0·0221
0·394	0·0039	0·0048	0·0063	0·0078	0·0095	0·0110	0·0125
0·472	0·0020	0·0029	0·0036	0·0045	0·0053	0·0063	0·0073
0·550	0·0010	0·0017	0·0024	0·0029	0·0034	0·0039	0·0044

In the siphon barometer the correction for capillarity is unnecessary, because the depressive force is equal on both sides. As mercury expands under the influence of heat, a correction must be made for *temperature*. A thermometer is attached to the best instruments, the bulb of which is placed in the cistern. It is necessary therefore, in comparing barometric heights at different places and at different temperatures, to calculate what the height of the mercury column at each place would have been if the temperature had been uniform; and it is usual to reduce the observed height of the column in each case to the height of a column of mercury that would produce the same pressure at 0° C. A further correction must also be made for the expansion of the scale on which the measurements are marked.

As the atmosphere is compressible, its density near the sea-level is greater than at places higher up, so that a barometer carried up a mountain indicates a continuously decreasing atmospheric pressure. From the difference in height of the mercury at two places, the difference of the elevation of the two stations is determined; but in order to reduce it to what it would be at the *sea-level*, an addition must be made to the observed reading at each place.

The *siphon* is an instrument the action of which depends on the atmospheric pressure; it is used for drawing off liquid from one vessel to another at a lower level than the former. It consists of a bent tube open at both ends, but having one leg, B D, longer than the other, B A (fig. 2, Plate XI.) The siphon, A B D, must first be filled with the liquid to be drawn off, and the short leg, B A, is temporarily closed, and then immersed in the reservoir, M N O P, from which the liquid is to be taken. It will be found that on opening it again a continuous stream of liquid will flow from the longer arm so long as the shorter arm, B A, dips into the fluid. Fig. 3 shows a form of siphon in which the shorter leg, A C, having been immersed into the liquid, the air is exhausted in the longer arm, A D, by means of the small suction tube E. So soon as the air is shown to be exhausted, by the rise of the liquid in E, on opening the stopcock, D, the liquid will flow, and the siphon may be shut off by closing the cock, D, as required. Various forms of siphons are shown in figs. 4, 5, 6, 7. Tantalus' cup (fig. 4) consists of a glass vessel, A B E F, containing the figure of Tantalus. A siphon tube passes from the bottom of the cup, H, and is concealed in the figure, the bend of the siphon, *h*, being level with the mouth of the figure. On water being poured into the cup, so soon as it is on a level with the mouth of the figure, the siphon has become charged, and the water passes through the tube into the lower chamber, C D, and thus disappears. The flow of intermittent springs may be explained by the action of this siphon. Many such springs furnish water for several days or even longer, and then, after the flow stops for a certain time, the spring will burst forth again. The subterranean cavities are more or less slowly filled by springs, and are then emptied by fissures so formed in the ground as to constitute a natural syphon. The intermittent flow of water from the siphon is explained as follows:—Taking the long arm, B C (fig. 8), the pressure within the tube at the point, D, in the plane of the surface of the liquid, is the same as at *a*, and is equal to the pressure of the atmosphere; while the pressure within the tube at C is greater than it is at D, or greater than the atmospheric pressure. Hence the liquid pressure at C overcomes that of the air from without, so that the column, B C, tends to separate at B, and to run out at C. If the height of B above *a* D be less than the height of a column of water in a barometer tube (34 feet), the pressure of the air will prevent any separation at B, and will keep up a continuous stream by forcing the water to ascend the shorter arm, *a* B. This will continue so long as the extremity of this arm is below the level of the water in the reservoir *a*. Fig. 5 is another form of siphon. The fountain, O, is kept playing by the pressure of the air upon the surface of the water in the chamber A F G H, and falling into the basin, R S, is emptied by the siphon, Q P, concealed in the body of the swan, into the chamber G E B, whence descending by the tube, L M, into the lower reservoir, C D E F, the pressure of the air is maintained by which the fountain, O, is kept in action. The stopcock in the tube L M is for the purpose of shutting off the flow of water and stopping the fountain. The action of the siphons *a b c*, in figs. 6 and 7, is obvious.

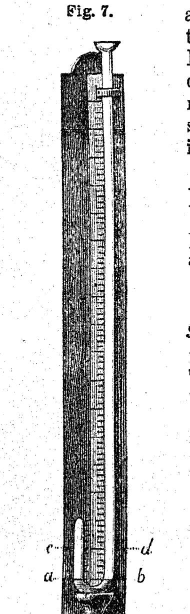
The *siphon gauge* is in general use for measuring small pressures, such as the pressure of gas supplied to houses, the pressure of the wind in organs, the amount of vacuum in sugar pans, &c. The liquid employed is usually water; when the pressure is extreme, as in the case of a vacuum or a steam gauge, mercury is employed. It consists of a bent glass tube with parallel legs, open at both ends, and partly filled with water. One leg of the tube is in connection with the gas the pressure of which is to be determined. If the pressure of the gas be greater than that of the atmosphere, the water will be forced up to a higher level in the other leg; if it be less, it will sink. Any excess of pressure beyond that of the atmosphere will be equal to the weight of the column of water raised, the height of which is the difference between the level of the liquid in the two tubes. Another form of pressure gauge, in which no fluid is employed, is that of *Bourdon*. It is one of great value, and has been in use over thirty-five years. Its invention was accidental. The worm pipe of a still had become flattened, and Mr. Bourdon, with a view to restore its cylindrical shape, forced water into it under pressure; as the flattened tube became more round, it uncoiled itself to a certain extent. Reasoning upon this tendency of the tube to uncoil, he was led to infer that this action of the tube might be applied in the construction of pressure gauges. The Bourdon gauge consists of a flattened tube open at one end and closed at the other, bent into a circular form. The open end is fixed to a rigid support, the closed end is left free and has attached to it a movable arm, which works a finely toothed quadrant, movable on a fixed centre. A small pinion carrying an index over a circular graduated scale, works into the quadrant. Any tendency of the tube to straighten by pressure passed into it through the fixed open end will therefore be communicated to the quadrant by the arm attached to the free end, and the pinion will revolve,

carrying the index over a portion of the graduated scale. This pressure gauge is largely employed for indicating the pressure of steam on locomotive and steam engine boilers, &c. When used as a vacuum gauge for the condenser of a steam engine, the tube becomes more flattened, and curves inwards as the air from the interior is exhausted, so that the action is the reverse of that when internal pressure is applied to the tube. The principle of the Bourdon gauge is frequently applied to the construction of very sensitive aneroid barometers. For this purpose the flattened tube is exhausted of air and closed at both ends. The action of the tube being more direct in the mechanical arrangements for multiplying the motion on the index, Bourdon barometers are in some respects more reliable than the other form of aneroid.

The two fundamental laws which govern the pressure of gases, are those of Boyle or Mariotte, and Charles or Gay-Lussac. Robert Boyle, born at Lismore, in Ireland, 1626, discovered the law of the compressibility of gases in 1662, and Mariotte rediscovered it in 1679. In England it is called Boyle's law, on the Continent Mariotte's law.

The characteristic qualities of all gases are their expansibility and compressibility, and it is necessary to consider the quantitative relation that exists between change of volume and change of pressure, the temperature remaining constant. The effect of atmospheric pressure is unperceived, because it is exerted equally in all directions. If a glass flask V, is full of air (fig. 9, Plate XI.), and provided with a stopcock C, although this may be closed, the glass of the flask will not be subject to any pressure by the weight of the external air, because the internal air exerts just as much pressure from within upon the flask in an opposite direction. But if by means of the air syringe A B (fig. 9), a portion of the air is withdrawn from the flask, the pressure of the particles within will no longer be able to counterbalance that of the external atmosphere, and the tendency will be to force the sides of the flask inwards. If half the mass of the air be withdrawn from within the flask, the internal pressure upon one square unit of surface will only be one half of what it was when the flask was full of air. If three-fourths of the air be removed, the pressure of the internal air will only be one-quarter, and so on. Thus the pressure of a mass of air confined in a vessel will be proportional to its mass. This may be stated thus:—*The pressure of a portion of gas at a given temperature varies inversely as the space it occupies.* A simple form of apparatus (fig. 7) for this experiment consists of a uniform bent tube, having one branch open at the top and considerably longer than the other, which is closed, or may be hermetically sealed by a screw cap, so that the pressure of the inclosed gas may be more easily regulated. A graduated scale is fixed to each branch of the tube. If the cap be unscrewed, and some mercury poured into the tube, it will rise to the same level, *a b*, in both branches, and when the cap is screwed on again some air will be inclosed under a pressure equal to that of the external atmosphere. Assume that this pressure is 76 centimetres, and that the level of the mercury in each branch be 0. When more mercury is poured into the longer arm of the tube, the level of the mercury in the shorter arm will be lower than that in the longer branch. The volume of air in the shorter arm is now reduced, and its pressure is increased by the weight of the column of mercury in the longer arm. If the air in the short arm originally occupied 20 divisions of the scale, or say 20 centimetres, and the height of the column of mercury in the longer arm is 23 centimetres above its former level 0, then the mercury in the short arm will stand at 4 centimetres above 0, and consequently the inclosed air will stand at 16 centimetres. The increased pressure due to the difference of level is therefore $23-4=19$ centimetres. If these numbers are examined it will be found that

Fig. 7.



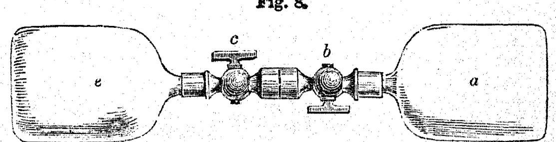
$$20:16::19+76:76, \text{ or as } 95:76, \text{ or } 20\times 76=16\times 95,$$

which shows that the variation in the volume of air is inversely as the variation in the pressure, or that the product of the volume into the pressure is constant, which may be stated as follows:—*The pressure of a gas is proportional to its density, the temperature remaining constant.* Boyle's law does not, however, appear to be absolutely general for all gases at all pressures, as Despretz has found that carbonic acid, sulphuretted hydrogen, ammonia, and cyanogen are more compressible than air; and that hydrogen, which has the same compressibility as air up to fifteen atmospheres, beyond that limit becomes less compressible. Regnault, by experiment, has found that air does not exactly follow Boyle's law, but experiences a greater compressibility which increases with the pressure, so that the difference between the calculated and the absolute diminution of volume is somewhat greater in proportion as the pressure increases. Carbonic acid exhibits considerable deviation from Boyle's law. Cailletel found that nitrogen at eighty atmospheres had a *maximum relative compressibility;* beyond this point it is less compressible, its compressibility diminishing more rapidly than that of hydrogen; and it has been found that the deviation from Boyle's law is greater in proportion as the gas is nearer its liquefying point, and the further a gas is from the liquefying point the more closely it follows the law.

Instruments for measuring the tension of gases or vapours are called *manometers*, and the unit chosen is the pressure of one atmosphere or 30 inches of mercury at the standard temperature. The *volumeter* or *sterometer* is another application of Boyle's law, and is of great value in determining the *gravimetrical density* of gunpowder, which averages from 1·67 to 1·84, and is very different from its apparent density which ranges from 0·89 to 0·94. It consists of a glass tube blown into a cylinder at the top, the edges of which are accurately ground, and which can be closed hermetically by a ground glass plate. The top of the cylinder being open, the tube is immersed in a vessel of mercury until the level inside the tube and outside is the same, which is then marked X on the tube. The cylinder is then closed hermetically by the glass plate, and the tube withdrawn from the mercury bath, until the mercury in the tube stand at a height, say h, above the level Q in the bath. The original volume of the inclosed air V in the cylinder is now increased to $V+v$, since the pressure has diminished by the height h of the column of mercury. If the pressure of the atmosphere at the time of observation is b, then $V:V+v::B-h:b$. The substance whose volume x is required to be ascertained, is now placed in the cylinder, and the same process repeated, the tube being raised until the mercury stands at the same mark as before, but its level above the mercury bath will now be changed; a second reading h, is obtained, and $(V-x):(V-x)+v::b-h:b$, from which the value of $x=(V+v)\,(1-\frac{h^1}{h})$. The volume $V+v$ is constant, and may be determined numerically by experiment with a substance of known volume.

Dalton's law is an extension of Boyle's law for a mixture of different gases. If several different gases which do not

Fig. 8.



Gases in Communicating Vessels.

chemically act on one another, are placed in a vessel, or in two communicating vessels, as $a\ e$ (fig. 8), connected by the stopcocks $b\ c$, they at once begin to mix whatever be their density, and the pressure on the sides of the vessel is the sum of the pressures due to the different gases. Let each of the gases, if in the vessel by itself, exert pressures, the intensities of which are repre-

sented by p_1, p_2, p_3, &c., respectively, the intensity of the whole pressure exerted by the mixture is $p_1+p_2+p_3$, &c. This law may be thus stated:—*When a mixture of several gases, at the same temperature, is contained in a vessel, each produces the same pressure as if the others were not present.*

Water and many liquids possess the property of absorbing gases. Water does not, however, absorb equal quantities of different gases, under similar conditions of pressure and temperature. It absorbs carbonic acid gas, and when strongly impregnated with this gas forms what is known as soda water. It also absorbs ammoniacal gas, forming liquid ammonia, and when saturated with hydrochloric acid gas, liquid hydrochloric acid, at a temperature of 0° C. and pressure 760 millimetres, one volume of water dissolves the following volumes of gas:—

Nitrogen, ...	0·020	Sulphuretted hydrogen,	4·37
Oxygen, ...	0·041	Sulphurous acid, . .	79·79
Carbonic acid, . . .	1·79	Ammonia, . . .	1046·63

Gases are more soluble in alcohol; at the same temperature alcohol will absorb 4·33 volumes of carbonic acid gas.

The general laws of gas-absorption, as investigated by Bunsen, are:—

I. *For the same gas, the same liquid, and the same temperature, the weight of gas absorbed is proportional to the pressure.*

II. *The volume of gas absorbed decreases with the temperature.*

III. *The volume of gas which a liquid can dissolve is independent of the nature and of the volume of other gases which it may already hold in solution.*

The phenomenon of endosmose is observable with gases in a higher degree than with liquids, but the laws of gaseous diffusion are simpler than those of liquid diffusion. These laws have been investigated by Graham, and may be stated as follows:—*The rates of diffusion of two gases into each other are in the inverse ratio of the square roots of their densities.* For, taking the density of air as *unity*, that of hydrogen is 0·0692; and the square roots of these numbers being 1 and 0·2632 respectively, by the law above stated, the rate of diffusion of hydrogen is to the rate of diffusion of air as $1:1\div0{\cdot}2632$, that is, $::1:3{\cdot}7994$; and by experiment it is found to be 3·83. The following table gives the results of some of Graham's experiments:—

Gas.	Density.	Square Root of Density.	$\frac{1}{\sqrt{\text{Density}}}$.	Rate of Diffusion.
Hydrogen, . . .	0·06926	0·2632	3·7994	3·83
Marsh gas, . . .	0·559	0·7476	1·3375	1·34
Carbonic oxide, .	0·9678	0·9837	1·0165	1·0149
Nitrogen, . . .	0·9713	0·9856	1·0147	1·0143
Oxygen, ...	1·1056	1·0515	0·9510	0·9487
Nitrous oxide, . .	1·527	1·0914	0·8092	0·82

If d and d' be the density of two gases, and D and D′ the volume of each which diffuses into the other in the same time, then, according to the law, $D:D'::\frac{1}{\sqrt{d}}:\frac{1}{\sqrt{d'}}$, or $D^2d=D'^2d'$.

The passage of gases into vacuum through minute apertures of about 0·013 millimetre in diameter is termed *effusion*, and the velocity of the efflux is measured by the formula $v=\sqrt{2gh}$, in which h represents the pressure under which the gas flows, expressed in terms of the height of a column of the gas which would exert the same pressure as that under which the gas flows. The ordinary pressure for air flowing into a vacuum is equivalent to a column of mercury 76 centimetres high; and mercury being about 10,500 times denser than air, the equivalent column of air will be 76 centimetres $\times$ 10,500, or 7980 metres. Therefore the velocity of air flowing into vacuum is equal to $\sqrt{2\times9{\cdot}8\times7980}$, or 395·5 metres. As the vacuum is always impaired by a continually increasing quantity of air, this velocity only holds for the first moment, the velocity becoming continually smaller, until it ceases altogether, when the pressure on each side is the same. When the height of the column of air, $h\,h'$, corresponding to the external pressure, is known, the velocity may be ascertained by the formula $v=\sqrt{2g}\,(h-h')$. From this it appears that *the velocities of efflux of different gases is inversely as the square roots of their densities.*

The surfaces of all solid bodies attract the particles of gases in contact with them, and become coated with a layer of *condensed gas* A porous substance, such as charcoal, which offers a very large surface in proportion to its bulk, will absorb considerable quantities of gas. Although there is no chemical combination between the solid and the gas, the absorption is in some measure influenced by the chemical nature both of the substance and the gas. The following table gives the volumes of gas, under standard conditions of pressure and temperature, absorbed by one volume of boxwood charcoal and of meerschaum respectively.

	Charcoal.		Meerschaum.
Ammonia, ...	90	...	15
Hydrochloric acid, . .	85	...	—
Sulphurous acid, . . .	65	...	—
Sulphuretted hydrogen, . .	55	...	11
Carbonic acid, ...	35	...	5·3
Carbonic oxide, ...	9·4	...	1·2
Oxygen, ...	9·2	...	1·5
Nitrogen, ...	7·5	...	1·6
Hydrogen, ...	1·75	...	0·5

The absorption of gases is generally greatest with those bodies which most readily liquefy. Cocoa-nut charcoal is highly absorbent; it absorbs 171 of ammonia and 73 of carbonic acid. The absorptive power of pine charcoal is about one-half that of boxwood charcoal, while corkwood charcoal, which is very porous, is not absorbent, neither is graphite. Platinum sponge absorbs 250 times its volume of oxygen gas. The phenomena known as "Moser's images" are due to the absorption of gases by solids. Thus, when a die or a coin is laid on a newly polished metal plate, the layer of vapour from the coin will diffuse on to the metal plate, the surface of which therefore becomes altered, so that when the coin is removed and the plate breathed upon an impression is visible.

The diffusion of gases may be explained by supposing the molecules of a gas as independent of one another, and that they are continuously moving in all directions, and with enormous velocity. As these molecules during their motion must constantly come into collision with one another, the direction of their motion becomes changed. When they come into contact with the sides of the vessel containing the gas their momentum is resisted; and it is to this shower of molecules moving with this great velocity that the pressure of a gas is supposed to be due. Dr. Joule, in 1848, demonstrated how the pressure of gases might be explained by the impact of their molecules, and he calculated the exact relation that exists between the observed pressure of a gas and the velocity of its molecules, so that if a vessel contained hydrogen gas at the ordinary pressure, and at 0° C., their velocity must be about 6055 feet per second. Although the velocity of these molecules is so great, the number of molecules occupying a given volume, say a cubic inch, is so enormous, that they can only move through very small spaces, and are unable to travel from side to side of the vessel containing them, without a series of successive impacts with other molecules moving with the same velocity. If therefore their average velocity remains the same, the pressure exerted at any point of the vessel containing the gas will depend on the number of molecules that impinge in a given time on the element of area containing that point. This pressure therefore will depend on the number of molecules contained in the vessel, or on the density of the gas; for if the volume of the gas be doubled, the average velocity of the molecules remaining the same, the number traversing a given area will be halved. As the density of a gas is the ratio of its mass to its volume, it follows that the pressure a gas exerts varies inversely with its volume, if its mass or the number of molecules in a given volume remain the same; and this result is the same as that obtained by experiment and known as "Boyle's law." The supposition

that all gases consist of a multitude of molecules moving about in all directions with a very high velocity is the basis of the *kinetic theory of gases.* This theory not only explains the phenomena of diffusion and Boyle's law, but likewise many other phenomena connected with the action of gases at various temperatures.

The pressure exerted by gases upon bodies immersed in them is transmitted equally in all directions, and the same laws which refer to the equilibrium of bodies in liquids apply to bodies in air, which lose a part of their weight equal to that of the volume of air they displace. Therefore gases as well as liquids possess buoyancy, and a body immersed in air becomes lighter by the weight of its bulk of air. This may be illustrated by attaching to one arm of a balance a large hollow sphere, and counterpoised by a small and heavy weight attached to the other arm, so that when in atmospheric air the weight of the two are exactly the same. If the balance be now placed under the receiver of an air-pump, and the air exhausted, the two arms of the scale will no longer be in equilibrium, but the weight of the globe will cause it to descend. The cause of this is that in vacuo the true weight is obtained, so that the sphere is in reality heavier than the weight employed to counterbalance it on the scale; but as the sphere is of much larger volume than the weight, it will apparently lose more weight through the displacement of the air than the latter, and though in air they appear to be of equal weight, the sphere is in reality the heavier, and the weight that will be required to be added to the balance to restore the equilibrium will be exactly that of the volume of air displaced by the sphere; for if the volume of the sphere be 10 cubic inches, the weight of this volume of air is 3·1 grains, and if this weight is added to the beam in vacuo it will exactly maintain the equilibrium, but in atmospheric air will overbalance the sphere. The principle of Archimedes applies equally to bodies immersed in air as to bodies in a liquid. When a body is heavier than air it sinks, but if lighter, volume for volume, it rises until it reaches a stratum of the same density as itself, and if of the same density it will remain suspended. It is from this cause that smoke, vapour, and air balloons rise in the air, and that clouds are held in suspension in the atmosphere.

The air balloon is simply a hollow sphere constructed of some light impervious material, such as varnished silk, which incloses a gas of a lighter specific gravity than the surrounding air. A valve is placed at the top of the sphere, and kept closed by a spring, but which can be opened when required by a cord attached to the car. The car is usually a light wickerwork basket suspended to the balloon by a network of cords which entirely cover the balloon. An ordinary sized balloon of 36 feet diameter and 48 feet in height, has buoyancy sufficient to carry three persons. The weight of the body of such a balloon is about 200 lbs., and that of the car and its accessories of ropes, &c., 100 lbs. more. The gas employed to inflate a gas balloon is either hydrogen gas or coal gas. Although the latter is more dense, it is generally employed, being cheaper and more readily obtained in quantities; it is passed into the interior of the balloon by means of a flexible tube attached to a gas main. The balloon should not be filled quite full of gas, otherwise when it ascends and the pressure of the atmosphere becomes lighter, the expansion of the gas would burst the covering of the balloon. Generally the inflation is so arranged that the weight of the displaced air exceeds that of the balloon by 8 or 10 lbs. This ascending force will remain constant so long as the balloon is not fully distended by the expansion of the contained gas. According to Boyle's law, if the atmospheric pressure has diminished one half, the gas in the balloon will have doubled its volume, and the volume of air displaced is therefore twice as great; but as the density is then only one half, the weight, and consequently the upward buoyancy, remain the same. When the balloon is fully distended, if it continues to rise, the velocity of the ascent diminishes as the volume of the displaced air remains constant; and when the buoyancy of the balloon is equal to that of the displaced air, it then simply floats and takes a horizontal direction according to the direction of the air currents in the upper regions of the atmosphere. By means of the barometer the aëronaut ascertains whether the balloon is ascending or descending, and can likewise determine the elevation obtained. If it is desired to descend, the valve is opened at the top of the balloon by pulling the cord, permitting a certain amount of gas to escape and the balloon to occupy a less volume of displacement. If, on the contrary, it is desired again to ascend, the weight of the balloon is reduced by the discharge of sand from the car. Various attempts have been made to effect some method of controlling the motion and direction of a balloon in the air, but so far without any practical result of value. Recent experiments in France have been successful to a certain limited extent, under very favourable atmospheric conditions, but at present the navigation of a balloon has not been accomplished. Balloons are now employed in military tactics to ascertain the position of an enemy from an elevation. At the battle of Solferino the movements of the Austrian troops were ascertained by the employment of a captive balloon. They were likewise employed during the American Civil War, 1862–64; during the Franco-Prussian War, 1870–71; and at the siege of Paris they rendered most valuable service, affording a means of escape from the beleaguered city, and as messengers carrying despatches, &c. The subject of military ballooning is now studied by the Royal Engineers, with a view of developing the most practical means of inflating balloons, and the best form of equipment for service in the field. The *parachute* is an appendage sometimes attached to the car of the balloon, for the purpose of effecting a separate descent. It consists of a large circular piece of silk, confined at the edges by cords, to which a small car is attached. The surface of the silk spreading out into the form of an umbrella, by the resistance of the air in falling, retards the velocity of the descent. A circular hole in the centre of the silk permits the escape of the compressed air, and somewhat steadies the oscillating motion produced, which when communicated to the car might prove dangerous to the occupant. When the cord attaching the parachute to the car of the balloon is cut it falls very rapidly at first, but the motion becomes arrested as the silk is distended and the resistance of the air increases.

ARITHMETIC.—CHAPTER VI.

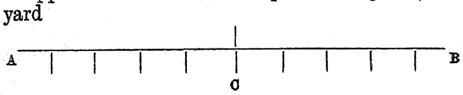
THE ARITHMETIC OF COMMON FRACTIONS.

WHEN we require to speak of quantity, time, space, &c., we choose some precise portion—any we please—and calling that, by convention, unity, we can then readily determine the relation which this portion bears to the quantity, time, space, &c., whose measure we desire to express. It may frequently happen, however, that the unit agreed upon, and which we call *one*, and represent by the symbol 1, is not an exact measure of the quantity—*e.g. length* proposed—there being a quantity even less than 1. Suppose for instance that
1 stands for the unit length ——
and that the length to be measured is 1 | 2 | 3 | x
then, this last can neither be expressed by 3 nor 4; it contains the unit agreed upon more than three times, and less than four times. To find a numerical expression for this length, therefore, we must either assign a new value to 1, or discover some way of expressing it in terms of the value already assigned. This last plan is manifestly the preferable one, as it avoids the interminable confusion which would result from our giving to the unit a value suited to every particular length, let us say, to be measured; and it is, moreover, very simply done. The method is this: we suppose the primitive unit—that is, the quantity which we have agreed to call unity, 1—to be broken down into any determinate number of equal parts, such that one of these parts shall be contained an exact number of times in the portion that is over. Thus in the foregoing instance, if the length denoted by 1 be divided into three equal parts, the portion of the second length which we have denoted by x will be equal to two of them; for

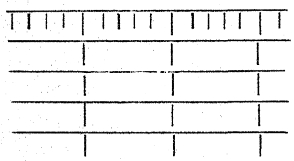
1 divided into 3 equal parts } is 1 | 2 | 3, two parts of which }
x divided into parts exactly equivalent } is 1 | 2, all the parts of which } are 1 | 2 .

That is, 2 of the 3 parts into which 1 is divided are equivalent to the whole portion x. The parts into which the length 1 is here divided we call *thirds*, and as 2 of these thirds exactly coincide with the portion x, we say that that portion contains 2 *thirds*, which we agree to write $\frac{2}{3}$: *the under figure showing the number of equal parts into which the primitive* 1 *or* UNIT *of measure is divided, and the upper the number of these parts contained in the quantity which it was required to measure.* A number expressed in this way we call a *fraction* (that is, a broken number, or a number formed by taking *parts* of the unit; from Lat. *fractus*, broken), when we wish to distinguish it from such numbers as 3, 7, 9, which we call *integers* or *whole numbers*, as being formed by the repetition of the [unbroken] unit.

Much depends upon our having a clear conception of the nature of a fraction, and it may be advisable to carry the explanation a step further. Suppose this practical case: Divide 17 yards into five equal portions, and tell the magnitude of each portion. To proceed by our rule for division, we get a quotient 3, and remainder 2; but the question requires further that these remaining 2 yards be likewise divided into five equal portions, and that one of these portions be annexed to the quotient quantity, 3 yards. This involves the question—if 2 yards be divided into 5 equal parts, what is the magnitude of each part? According to the principle just explained, the answer is $\frac{2}{5}$. That this is right is made obvious thus—suppose that the line A B represents 2 yards, and that each yard



is divided into five equal parts: the whole is thereby divided into *ten* new units, each of which is the fifth part of the original unit or yard. Now in order to find a fifth part of the whole length A B, it is manifestly enough to take *one-fifth* of A C + *one-fifth* of C B; but these parts are together as manifestly equal to *two* of the *fifths* of the unit A C. This we express by $\frac{2}{5}$, and is the quantity which we must add to 3 yards, to make up the fifth part of 17 yards. The five portions into which the 17 yards are divided may therefore be representatively put down thus:—



that is, 3 yds. + 2-fifths.
" 3 yds. + 2-fifths.
" 3 yds. + 2-fifths.
" 3 yds. + 2-fifths.
" 3 yds. + 2-fifths.

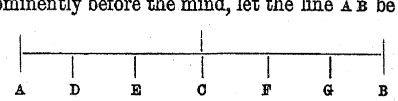
the sum of which is 15 yds. + 10-fifths = 17 yds.

The same kind of reasoning is applicable to the division of 17 gallons of water, 17 acres of land, 17 bushels of corn, or 17 units of anything we please, into five equal parts; and therefore we conclude generally that the fifth part of 17 is 3 and $\frac{2}{5}$, which we might write $3+\frac{2}{5}$, but, for shortness, usually $3\frac{2}{5}$. But $\frac{2}{5}$ is the same symbol as would be formed by writing the remainder 2 above and the divisor 5 beneath a horizontal line, as directed by the rule for division, to denote the process that one number is to be divided by another. Accordingly, we may regard every case of division so expressed as a fraction, and every fraction as a division to be performed. In harmony with this view $\frac{17}{5}$, $\frac{34}{10}$, $\frac{51}{15}$, are each fractions; and the term fraction may even be extended to whole numbers: for example, $\frac{17}{1}$, $\frac{34}{2}$, $\frac{51}{3}$, are fractions, and are all equal to and representative of the whole number 17.

According to this new notation, which includes all our former ideas of number, and others besides, the part above the line is called the *numerator*, and that beneath it, the *denominator*, and both of these are called the *terms* of the fraction. The *numerator* takes its name from its expressing the *number* of parts of a certain kind that are taken; the *denominator*, from its giving *name*, as *sevenths*, *ninths*, to the parts into which the unit is (to be regarded as) divided.

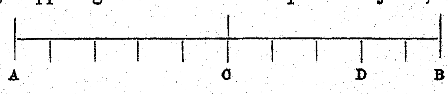
As long as the numerator is less than the denominator, the fraction is less than unity [1]; thus, $\frac{19}{20}$ is less than 1: for the denominator is the unit divided into 20 parts, and we must therefore have 20 such parts to make 1; but the fraction $\frac{19}{20}$ shows that the quantity considered contains only 19 such parts Similarly, $\frac{7}{11}$, $\frac{11}{12}$, $\frac{33}{35}$, are all less than 1, and are sometimes, for that reason, termed *proper fractions*. On the other hand, when the numerator is equal to, or exceeds the denominator, the fraction is equal to, or greater than unity [1]; thus $\frac{5}{5}$ is equal to 1, for it is the fifth part of 1 repeated 5 times, or it is the magnitude of each of the parts which result from dividing 5 into 5 equal parts. Similarly, $\frac{4}{4}$, $\frac{9}{9}$, $\frac{12}{12}$, $\frac{29}{29}$, are all equal to unity [1], and consequently equal to each other. But $\frac{12}{7}$ is greater than 1: for the unit is here divided into 7 parts only, and the numerator consists of 12 or 7+5 such parts; that is, of a whole *unit* and *five-sevenths* of a unit over, or using signs $\frac{12}{7}=1\frac{5}{7}$. Expressions such as $\frac{5}{5}$, $\frac{12}{7}$, in which the numerator is equal to or exceeds the denominator, are usually called *improper fractions;* and when an expression consists of a whole number and a fraction, as $1\frac{5}{7}$, it is commonly called a *fractional* or *mixed number*.

There are two ways in which a fraction may be considered. If we have, for instance, such a fraction as $\frac{2}{3}$, we may regard it either as the third part of 2, or as twice the third part of 1. This is, indeed, plain from what has been said upon the division of 17 by 5. In order, however, to bring the principle more prominently before the mind, let the line A B be 2 yards;



and divide each of the yards A C and C B into three equal parts. Then because A E = E F = F B, and divide the length A B into three parts, A E is the third part of 2: it is therefore $\frac{2}{3}$. But A E is twice A D, and A D is the third part of 1 yard A C; and a third of 1 is $\frac{1}{3}$. Therefore A E = $\frac{2}{3}$ is twice $\frac{1}{3}$. Hence to get a length equal to two-thirds of a yard, it makes no difference whether we divide *two yards* into three equal parts and take *one* of each of them, or whether we divide *one yard* into three equal parts and take *two* of them. The symbol $\frac{2}{3}$ is made to stand for each of these operations, since they both lead to the same result. By the same sort of reasoning we conclude that *one-fifth* of *three*, and *three-fifths* of *one*, are identical and truly expressed by $\frac{3}{5}$; and this double interpretation may be extended to all other cases.

The meaning may appear to be somewhat ambiguous when the numerator of the fraction is greater than the denominator. According to the latter interpretation, $\frac{8}{5}$ would mean that 1 is divided into 5 equal parts, and that 8 of them are to be taken. The explanation is, however, very easy; the case requires simply that as many units be each divided into fifths as will give more than 8 such parts, and that 8 of them are to be taken to form the numerator of the fraction. Thus, supposing the line A B to represent 2 yards, divided



each into five equal parts; the whole number of parts is 10, and of these we are to take eight, namely, A D, to form our fraction; and as each part is a fifth of 1 yard, eight such fifths is truly expressed by $\frac{8}{5}$.

In arithmetical works it is common to give a rule for finding the integers contained in an improper fraction. The necessity for such a rule has, however, been obviated by the explanation that every fraction may be regarded as a division to be performed. If wanted, however, the rule is: *Divide*

the numerator by the denominator—e.g. how many units are there in $\frac{23}{6}$? Since $\frac{6}{6}=1$, it is plain that as often as $\frac{23}{6}$ contains $\frac{6}{6}$ so many units there will be. Now $23=6+6+6+5$; therefore,

$$\frac{23}{6}=\frac{6}{6}+\frac{6}{6}+\frac{6}{6}+\frac{5}{6}=1+1+1+\frac{5}{6}=3+\frac{5}{6} \text{ or } 3\frac{5}{6}$$

This agrees with the rule; for $23 \div 6$ give 3 for quotient and 5 for remainder; and the sixth part of 5 is $\frac{5}{6}$; therefore

$$23 \div 6 = 3 + \frac{5}{6} \text{ or } 3\frac{5}{6}$$

Similarly

$\frac{39}{5}=39 \div 5 = 7+\frac{4}{5}$	$\frac{150}{14}=150 \div 14 = 10\frac{10}{14}$
$\frac{83}{11}=83 \div 11 = 7\frac{6}{11}$	$\frac{307}{15}=307 \div 15 = 20\frac{7}{15}$

The counterpart of this problem—viz. the conversion of whole and mixed numbers into fractions—is frequently needed. The rule is this: *Multiply the integral part by the given denominator, and the product increased by the numerator of the fractional part (if there be any such part) is the numerator of the new fraction.*

As an example, express 3 in *fifths.* Since every 1 in 3 is $\frac{5}{5}$, therefore $3=\frac{5+5+5}{5}=\frac{5\times 3}{5}=\frac{15}{5}$.

Again, how many eighths in $7\frac{3}{8}$? In 7 there are, reasoning as before, 7×8, or 56 eighths; therefore 7 and 3 eighths must contain $56+3$, or 59 eighths; consequently $7\frac{3}{8}=\frac{59}{8}$.

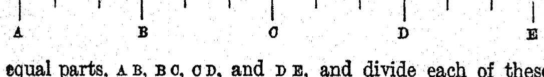
Similarly

7 expressed in ninths is $\frac{63}{9}$	$9\frac{11}{12}$ expressed in twelfths, $\frac{119}{12}$
$7\frac{1}{3}$ " in thirds, $\frac{22}{3}$	3 " in hundredths, $\frac{300}{100}$

These two processes are the inverse of each other, and mutually prove each other's results, as may be easily seen by working the answer of the one as the question of the other.

We come now to consider, perhaps, the most valuable property of a fraction. We have shown that the dividend and divisor may be either multiplied or divided by the same number without affecting the quotient. As the greater part of the operations upon fractions have an immediate reference to the principle involved, the student cannot be too particular in impressing it upon his mind. It is the following:—

The value of a fraction is not altered by multiplying *both* its numerator and denominator by the same quantity. That is, $\frac{3}{4}$ is the same as $\frac{9}{12}$; or we shall obtain the result by dividing 1 yard into 12 parts, and taking 9 of them, and by dividing it into 4 parts and taking three of them. To prove this, let A E be a yard or any other definite length; divide it into 4



equal parts, A B, B C, C D, and D E, and divide each of these parts into 3 equal parts; then A D is $\frac{3}{4}$. But it is also $\frac{9}{12}$, for the whole line is divided into 12 equal parts, and A D contains 9 of them; that is, we get the same length by dividing a yard into 12 equal parts, and taking 9 of them, as we get by dividing it into 4 equal parts, and taking 3 of them. We have, therefore, no difficulty in concluding generally that $\frac{3}{4}$ and $\frac{9}{12}$ are the same thing. It follows from this that every fraction admits of innumerable alterations in its form without suffering any change of value.

Thus

$$\frac{1}{2}=\frac{2}{4}=\frac{3}{6}=\frac{4}{8}=\frac{5}{10}=\frac{6}{12}=\frac{7}{14}=\frac{8}{16}=\&c.$$

$$\frac{2}{7}=\frac{4}{14}=\frac{6}{21}=\frac{8}{28}=\frac{10}{35}=\frac{12}{42}=\frac{14}{49}=\frac{16}{56}=\&c.$$

On the same principle, the terms of a fraction may both be divided by any number without any alteration of its value. This hardly needs demonstration; for $\frac{3}{4}$ and $\frac{9}{12}$ are the same, and $\frac{3}{4}$ is made from $\frac{9}{12}$, by dividing both numerator and denominator by 3.

Though the two fractions $\frac{3}{4}$ and $\frac{9}{12}$ are of the same value, and either of them may be used for the other without error, yet the first is more convenient than the second, not only because we have a clearer idea of *three-fourths* of a yard than of *nine-twelfths* of it; but the numbers in the first being smaller, they are more conveniently added, subtracted, multiplied, or divided. It is therefore useful, when a fraction is given, to find out whether its terms have any common divisor or measure. The method of doing this has already been explained (pp. 412–415). There it was shown, that when two numbers are divided by their greatest common measure, the quotients are *prime* to each other. When the terms of a fraction are thus reduced, that is, are incapable of being both measured by any number greater than 1, the fraction is said to be reduced to its *lowest terms*, and cannot be expressed more simply or by any fraction having a smaller numerator and denominator. From all this it appears that a fraction is reduced to its lowest terms when its numerator and denominator are divided by their greatest common measure, or in other words, have all their common factors expunged.

It frequently happens that the greatest common measure is evident on inspection, as in the following instances, where the common factors are accented:—

$\frac{8}{12}=\frac{2\times 4'}{3\times 4'}=\frac{2}{3}$	$\frac{9}{81}=\frac{1\times 9'}{9\times 9'}=\frac{1}{9}$	$\frac{28}{35}=\frac{4\times 7'}{5\times 7'}=\frac{4}{5}$
$\frac{12}{48}=\frac{1\times 12'}{4\times 12'}=\frac{1}{4}$	$\frac{14}{21}=\frac{2\times 7'}{3\times 7'}=\frac{2}{3}$	$\frac{24}{21}=\frac{8\times 3'}{7\times 3'}=\frac{8}{7}$

When, however, the terms of the fraction are large numbers, it becomes necessary to apply the rule for finding the greatest common measure of two numbers in order to eliminate the common factor of the terms. The following are instances:—

$\frac{2433}{13787}=\frac{3\times 811'}{17\times 811'}=\frac{3}{17}$	$\frac{8888}{403596}=\frac{22\times 404'}{999\times 404'}=\frac{22}{999}$
$\frac{1397}{2921}=\frac{11\times 127'}{23\times 127'}=\frac{11}{23}$	$\frac{13786}{93208}=\frac{113\times 122'}{764\times 122'}=\frac{113}{764}$

Where the terms of the fraction are already in factors, any one factor in the numerator may be divided or struck out, provided the same is done with some one factor in the denominator.—The *Principle* is the same as before.

$\frac{4\times 7\times 5}{8\times 6\times 10}=\frac{1'\times 7\times 1'}{2'\times 6\times 2'}=\frac{7}{2\times 6\times 2}=\frac{7}{24}$	$\frac{21\times 16\times 4}{14\times 32\times 8}=\frac{3}{8}$
$\frac{12\times 18\times 33}{18\times 24\times 11}=\frac{2'\times 3'\times 3'}{3'\times 4'\times 1'}=\frac{1'\times 1'\times 3}{1'\times 2'\times 1}=\frac{3}{2}$	$\frac{7\times 25\times 30}{28\times 35\times 100}=\frac{3}{56}$

Since the relative magnitudes of fractions depend upon two numbers, it is not always easy, at first sight, to decide which of two quantities so expressed is the greater, especially if the terms are high numbers. For instance, take $\frac{4}{5}$ and $\frac{13}{15}$. Before we can compare their values, or express their sum or difference by a single number, we must effect such a change on one or both of them, that their component units shall be the same. Let the terms of $\frac{4}{5}$ be multiplied by 15, and the terms of $\frac{13}{15}$ by 5, then $\frac{4}{5}$ becomes $\frac{60}{75}$, and $\frac{13}{15}$ becomes $\frac{65}{75}$, and as these new fractions have the same values as those given and express similar parts of the same unit, *for the denominator in both is the same*, we are able to determine their relative magnitudes, and, as we shall afterwards see, can find their sum or their difference with comparative readiness.

To show how this is done, we shall work out an example. Let the proposed fractions be $\frac{1}{2}$, $\frac{3}{4}$, $\frac{5}{6}$, $\frac{2}{3}$. Multiply both terms of $\frac{1}{2}$ by $4\times 6\times 3$, both terms of $\frac{3}{4}$ by $2\times 6\times 3$, both terms of $\frac{5}{6}$ by $2\times 4\times 3$, both terms of $\frac{2}{3}$ by $2\times 4\times 6$; then it appears that

$\frac{1}{2}$ is $\frac{1\times4\times6\times3}{2\times4\times6\times3}$ or $\frac{72}{144}$ | $\frac{5}{6}$ is $\frac{5\times2\times4\times3}{6\times2\times4\times3}$ or $\frac{120}{144}$

$\frac{3}{4}$ is $\frac{3\times2\times6\times3}{4\times2\times6\times3}$ or $\frac{108}{144}$ | $\frac{2}{3}$ is $\frac{2\times2\times4\times6}{3\times2\times4\times6}$ or $\frac{96}{144}$

We have thus succeeded in bringing all the given fractions to the same denominator, 144, and the method by which it is done is as follows:—

Multiply each numerator by all the given denominators except its own, for the numerator of the equivalent fraction, and take the product of ALL *the denominators for its denominator.*

This is the common rule; and it is obvious at once that by following it we must always succeed in forming a new set of fractions, having a common denominator. But, on examining the resulting fractions in the foregoing example, we find that all the numerators and the common denominator are divisible by 12; and we have already shown that this division does not affect their value. Making therefore this division, we get

$\frac{6}{12}$ instead of $\frac{72}{144}$ | $\frac{10}{12}$ instead of $\frac{120}{144}$

$\frac{9}{12}$ " $\frac{108}{144}$ | $\frac{8}{12}$ " $\frac{96}{144}$

These are likewise fractions equivalent to those given, and have a common denominator; but the common denominator is a much smaller number, and therefore they are simpler answers to the question than the fractions first found, and are much more easily worked with. Our first object properly is to find equivalent fractions having a common denominator; but, as a matter of course, it is of great importance that the denominator be as small as possible, and this is always the case when the numerators and this denominator have no common measure. The common denominator which fulfils these conditions is the least common multiple of all the denominators given, and is found as explained, p. 413. The method of proceeding will be best understood by an example. Let the given fractions be

$$\frac{1}{2}\quad \frac{2}{3}\quad \frac{3}{4}\quad \frac{7}{6}\quad \frac{9}{10}\quad \frac{5}{12}\quad \frac{17}{18}\quad \frac{8}{21}$$

Find the least *common multiple* of these denominators; it is 1260. The equivalent fractions to be found cannot obviously have a less common denominator than this, and it need not be greater. Taking 1260 therefore as the denominator wanted, we find a set of multipliers for the numerators of the given fractions, simply by dividing the multiplier by all the denominators in succession.

Thus $1260\div2=630$ | $1260\div4=315$ | $1260\div10=126$
$1260\div3=420$ | $1260\div6=210$ | $1260\div12=105$
$1260\div18=70$ $1260\div21=60$

We now multiply every given numerator by the result of its denominator in the preceding list, for the numerator of the equivalent fraction, and write 1260 for the common denominator of all, as follows:—

$1\times630=\ 630$; therefore $\frac{1}{2}$ is $\frac{630}{1260}$

$2\times420=\ 840$; therefore $\frac{2}{3}$ is $\frac{840}{1260}$

$3\times315=\ 945$; therefore $\frac{3}{4}$ is $\frac{945}{1260}$

$7\times210=1470$; therefore $\frac{7}{6}$ is $\frac{1470}{1260}$

$9\times126=1134$; therefore $\frac{9}{10}$ is $\frac{1134}{1260}$

$5\times105=\ 525$; therefore $\frac{5}{12}$ is $\frac{525}{1260}$

$17\times\ 70=1190$; therefore $\frac{17}{18}$ is $\frac{1190}{1260}$

$8\times\ 60=\ 480$; therefore $\frac{8}{21}$ is $\frac{480}{1260}$

The following instances may be managed exactly in the same way, and will afford sufficient exercise in the rule, should they be worked over with care.

Fractions given.	Reduced to a common Denominator.
$\frac{1}{2}\ \frac{2}{3}\ \frac{3}{4}\ \frac{1}{6}\ \frac{3}{8}\ \frac{5}{12}$	$\frac{12}{24}\ \frac{16}{24}\ \frac{18}{24}\ \frac{4}{24}\ \frac{9}{24}\ \frac{10}{24}$
$\frac{1}{3}\ \frac{2}{7}\ \frac{3}{14}\ \frac{12}{21}\ \frac{3}{4}$	$\frac{28}{84}\ \frac{24}{84}\ \frac{18}{84}\ \frac{48}{84}\ \frac{63}{84}$
$\frac{3}{4}\ \frac{5}{9}\ \frac{9}{10}\ \frac{7}{12}\ \frac{1}{18}$	$\frac{135}{180}\ \frac{100}{180}\ \frac{162}{180}\ \frac{105}{180}\ \frac{10}{180}$
$\frac{1}{2}\ \frac{1}{3}\ \frac{1}{4}\ \frac{1}{5}\ \frac{1}{6}$	$\frac{30}{60}\ \frac{20}{60}\ \frac{15}{60}\ \frac{12}{60}\ \frac{10}{60}$
$\frac{5}{8}\ \frac{7}{12}\ \frac{11}{18}\ \frac{9}{20}\ \frac{5}{24}$	$\frac{225}{360}\ \frac{210}{360}\ \frac{220}{360}\ \frac{162}{360}\ \frac{75}{360}$
$\frac{1}{9}\ \frac{3}{5}\ \frac{7}{15}\ \frac{5}{6}\ \frac{16}{24}\ \frac{11}{27}$	$\frac{120}{1080}\ \frac{648}{1080}\ \frac{504}{1080}\ \frac{900}{1080}\ \frac{720}{1080}\ \frac{440}{1080}$

THE LATIN LANGUAGE.—CHAPTER VII.

IRREGULAR VERBS.

IRREGULARITIES of three kinds occur in Latin verbs:—(1) Some of the tenses of Latin verbs (especially the perfect and the supine) are formed in a different way from that shown in the paradigms of the regular verbs; (2) some verbs have peculiarities in the mode of adding their inflexions to the stem, as *fero*, &c.; (3) sometimes two or more different stems are used to complete one verb: as present, *sum;* perfect, *fui;* present, *fĕro;* perfect, *tŭli;* supine, *lātum.* Properly speaking, this last distinction ought not to be regarded as an irregularity: it is rather a case of totally different stem, and such verbs should be called composite.

The number of verbs irregular in the perfect and supine is very large; but there are eleven verbs of such frequent occurrence, and so peculiarly irregular, that it is usual to print them at length, that they may be specially committed to memory and be readily referred to. These are—*sum*, and its compounds *possum, prosum*, &c., of which we have already supplied complete paradigms, and *vŏlo, nōlo, mālo, eo, fio, fĕro, ĕdo*, and *queo*, with its compound *nĕqueo*, to which we now direct attention.

The anomalous verbs, *volo*, I wish; *nolo*, I wish not to; *malo*, I would rather; *fero*, I bear; and *eo*, I go, do not form all their parts in the usual way, but are conjugated irregularly, thus:—

INDICATIVE MOOD.

PRESENT.

S.	1.	Vŏlo,	Nōlo,	Mālo,	Fĕro,	Eo.
	2.	Vīs,	Nonvīs,	Māvis,	Fers,	Is.
	3.	Vult,	Nonvult,	Māvult,	Fert,	It.
Pl.	1.	Vŏlŭmŭs,	Nōlŭmŭs,	Mālŭmŭs,	Fĕrĭmŭs,	Imŭs.
	2.	Vultĭs,	Nonvultĭs,	Māvultĭs,	Fertĭs,	Itĭs.
	3.	Vŏlunt,	Nōlunt,	Mālunt,	Fĕrunt,	Eunt.

IMPERFECT.

S.	1.	Vŏlē -bam,	Nōlē -bam,	Mālē -bam,	Fĕrē -bam,	I -bam.
	2.	-bās,	-bās,	-bās,	-bās,	-bās.
	3.	-băt,	-băt,	-băt,	-băt,	-băt.
Pl.	1.	-bāmŭs,	-bāmŭs.	-bāmŭs,	-bāmŭs,	-bāmŭs.
	2.	-bātĭs,	-bātĭs,	-bātĭs,	-bātĭs,	-bātĭs.
	3.	-bant,	-bant,	-bant,	-bant,	-bant.

FUTURE SIMPLE.

S.	1.	Vŏl -am,	Nōl -am,	Māl -am,	Fĕr -am,	I -bo.
	2.	-ēs,	-ēs,	-ēs,	-ēs,	-bĭs.
	3.	-ĕt,	-ĕt,	-ĕt,	-ĕt,	-bĭt.
Pl.	1.	-ēmŭs,	-ēmŭs,	-ēmŭs,	-ēmŭs,	-bĭmŭs.
	2.	-ētĭs,	-ētĭs,	-ētĭs,	-ētĭs,	-bĭtĭs.
	3.	-ent,	-ent,	-ent,	-ent,	-bunt.

PERFECT.

S.	1.	Vŏlŭ -i,	Nōlŭ -i,	Mālŭ -i,	Tŭl -i,	Iv -i.
	2.	-istī,	-istī,	-istī,	-istī,	-istī.
	3.	-ĭt,	-ĭt,	-ĭt,	-ĭt,	-ĭt.
Pl.	1.	-ĭmŭs,	-ĭmŭs,	-ĭmŭs,	-ĭmŭs,	-ĭmŭs.
	2.	-istĭs,	-istĭs,	-istĭs,	-istĭs,	-istĭs.
	3.	-ērunt, *or* ēre,	-ērunt, *or* ēre,	-ērunt, *or* ēre,	-ērunt, *or* ēre,	-ērunt, *or* ēre.

PLUPERFECT.

S. 1.	Vŏlŭ-ĕram,	Nōlŭ-ĕram,	Mālŭ-ĕram,	Tŭl-ĕram,	Iv-ĕram.
2.	-ĕrās,	-ĕrās,	-ĕrās,	-ĕrās,	-ĕrās.
3.	-ĕrăt,	-ĕrăt,	-ĕrăt,	-ĕrăt,	-ĕrăt.
Pl. 1.	-ĕrāmŭs,	-ĕrāmŭs,	-ĕrāmŭs,	-ĕrāmŭs,	-ĕrāmŭs.
2.	-ĕrātĭs,	-ĕrātĭs,	-ĕrātĭs,	-ĕrātĭs,	-ĕrātĭs.
3.	-ĕrant,	-ĕrant,	-ĕrant,	-ĕrant,	-ĕrant.

FUTURE PERFECT.

S. 1.	Vŏlŭ-ĕro,	Nōlŭ-ĕro,	Mālŭ-ĕro,	Tŭl-ĕro,	Iv-ĕro.
2.	-ĕris,	-ĕris,	-ĕris,	-ĕris,	-ĕris.
3.	-ĕrĭt,	-ĕrĭt,	-ĕrĭt,	-ĕrĭt,	-ĕrĭt.
Pl. 1.	-ĕrimŭs,	-ĕrimŭs,	-ĕrimŭs,	-ĕrimus,	-ĕrimŭs.
2.	-ĕritĭs,	-ĕritĭs,	-ĕritĭs,	-ĕritĭs,	-ĕritĭs.
3.	-ĕrint,	-ĕrint,	-erint,	-ĕrint,	-ĕrint.

SUBJUNCTIVE MOOD.

PRESENT.

S. 1.	Vĕl-im,	Nōl-im,	Māl-im,	Fĕr-am,	E-am.
2.	-īs,	-īs,	-īs,	-ās,	-ās.
3.	-ĭt,	-ĭt,	-ĭt,	-ăt,	-ăt.
Pl. 1.	-īmŭs,	-īmŭs,	-īmŭs,	-āmŭs,	-āmŭs.
2.	-ītĭs,	-ītĭs,	-ītĭs,	-ātĭs,	-ātĭs.
3.	-int,	-int,	-int,	-ant,	-ant.

IMPERFECT.

S. 1.	Vell-em,	Noll-em,	Mall-em,	Ferr-em,	Ir-em.
2.	-ēs,	-ēs,	-ēs,	-ēs,	-ēs.
3.	-ĕt,	-ĕt,	-ĕt,	-ĕt,	-ĕt.
Pl. 1.	-ēmŭs,	-ēmŭs,	-ēmŭs,	-ēmŭs,	-ēmŭs.
2.	-ētĭs,	-ētĭs,	-ētĭs,	-ētĭs,	-ētĭs.
3.	-ent,	-ent,	-ent,	-ent,	-ent.

PERFECT.

S. 1.	Vŏlŭ-ĕrim,	Nōlŭ-ĕrim,	Mālŭ-ĕrim,	Tŭl-ĕrim,	Iv-ĕrim.
2.	-ĕris,	-ĕris,	-ĕris,	-ĕris,	-ĕris.
3.	-ĕrĭt,	-ĕrĭt,	-ĕrĭt,	-ĕrĭt,	-ĕrĭt.
Pl. 1.	-ĕrimŭs,	-ĕrimŭs,	-ĕrimŭs,	-ĕrimŭs,	-ĕrimŭs.
2.	-ĕritĭs,	-ĕritĭs,	-ĕritĭs,	-ĕritĭs,	-ĕritĭs.
3.	-ĕrint,	-ĕrint,	-ĕrint,	-ĕrint,	-ĕrint.

PLUPERFECT.

S. 1.	Vŏlŭ-issem,	Nōlŭ-issem,	Mālŭ-issem,	Tŭl-issem,	Iv-issem.
2.	-issēs,	-issēs,	-issēs,	-issēs,	-issēs.
3.	-issĕt,	-issĕt,	-issĕt,	-issĕt,	-issĕt.
Pl. 1.	-issēmŭs,	-issēmŭs,	-issēmŭs,	-issēmŭs,	-issēmŭs
2.	-issētĭs,	-issētĭs,	-issētĭs,	-issētĭs,	-issētĭs.
3.	-issent,	-issent,	-issent,	-issent,	-issent.

IMPERATIVE MOOD.

PRESENT.

S. 2.	—	Nōlī,	—	Fĕr,	I.
Pl. 2.	—	Nōlīte,	—	Ferte,	Ite.

FUTURE.

S. 2.	—	Nōlīto,	—	Ferto,	Ito.
3.	—	Nōlīto,	—	Ferto,	Ito.
Pl. 2.	—	Nōlītōte,	—	Fertōte,	Itōte.
3.	—	Nōlunto,	—	Ferunto,	Eunto.

INFINITIVE MOOD.

PRESENT.

Velle,	Nolle,	Malle,	Ferre,	Ire.

PERFECT.

Vŏlŭ-isse,	Nōlŭ-isse,	Mālŭ-isse,	Tŭl-isse,	Iv-isse.

GERUNDS.

—	—	—	Fĕrend-um,	Eund-um.
Vŏlend-ī,	Nōlend-ī,	Mālend-ī,	Fĕrend-ī,	Eund-ī.
Vŏlend-o,	Nōlend-o,	Mālend-o,	Fĕrend-o,	Eund-o.

SUPINE.

—	—	—	Lāt-um,	It-um.
—	—	—	Lāt-ū,	It-ū.

PARTICIPLES.

PRESENT.

Vŏlens,	Nōlens,	Mālens,	Fĕrens,	Iens (ĕunt-ĭs).

FUTURE.

—	—	—	Lāt-ūrŭs,	It-ūrŭs.

Fĕror (passive) has second person present indicative, *ferrĭs;* third person, *fertŭr;* imperfect subjunctive, *fērrĕr*, *ferrēris*, &c.; and infinitive, *ferrī*. Supine stem-forms, *lātŭs sum*, &c.

Fīo is (in the present stem-forms) used as the passive of *făcĭo*, which is regular in the active and in the supine stem-forms of the passive.

Edo, I eat, though its other forms are regular, often changes some of its parts as follows :—

Second person present singular, *ĕdĭs* or *ēs;* third person singular, *ĕdit* or *est;* infinitive, *ĕdĕre* or *esse;* imperfect subjunctive, *ĕdĕrem* or *essem.*

In the present subjunctive, *ĕdim*, *ĕdīs*, *ĕdĭt* are used.

Eo has a passive voice only in the third singular ; as *ītur*, it is gone; *ibatur*, it was gone, &c. The compounds of *eo* (*abeo*, to go away; *ineo*, to enter; *redeo*, to return, &c.) are conjugated like the simple verb; but *ivi*, *ivisti*, &c., in the perfect, are usually contracted into *ii*, *iisti* (*isti*). Some of the compounds occasionally take *-am* instead of *-bo* in the future; as *redeam*, *redies*, &c. Some are transitive, and therefore have a complete passive voice; as *adeo*, *ineo*, *prætereo*, *transeo*, &c. The compound *vēneo*, I am sold (which has a passive signification, and is contracted for *venum eo*), is conjugated like the simple verb, but wants the imperative, the participles, and the gerund. Its imperfect indicative is often made *veniēbam*, for *venībam.* The compound *ambio* is a regular verb of the Fourth Conjugation; as *ambiunt*, *ambiebam* or *ambibam*, *ambiam*, &c.

Queo, I am able, and *nequeo*, I am unable, are conjugated like *eo;* but they want the imperative and the gerund. Their participles very seldom occur. They are occasionally used in the passive voice when governing the infinitive passive of another verb. *Non quis* and *non quit* are used for *nequis* and *nequit.*

Many of these irregularities of inflexion are the result of syncope, contraction, or the requirements of the laws of euphony.

In verbs which have *v* in their perfect tense contraction often takes place by omitting the *v*, after which the first vowel of the termination is absorbed into the final vowel of the stem; as *amāsti*, for *amāvisti; nōram*, for *nōvĕram; complērunt*, for *complēvērunt; nōsse*, for *nōvisse.* When an *i* precedes *v* the *v* is not unfrequently omitted without this absorptive contraction; as *finiero*, for *finivero.*

In verbs which have perfect stems ending in *s* or *x* the syllables *is*, *iss*, and *sis* of the termination are occasionally omitted in the perfect and in tenses derived from it. This occurs more particularly in verbs of the Third Conjugation; as *evasti*, for *evasisti; extinxem*, for *extinxissem; justi*, for *jussisti; divisse*, for *divisisse.*

The third person singular of the perfect is often contracted in verbs of the First, Second, and Fourth Conjugations; as *fumāt*, for *fumāvit; audīt*, for *audīvit.* This form, of course, occurs most frequently in poetry.

The supine in *-um* is found in comparatively few—some say not more than 300—verbs. It is, however, in most grammars inserted for uniformity's sake; as though in many verbs it does not actually occur in extant books, its existence is implied in the perfect participle passive or the future in *-rus:* and hence the neuter of the perfect participle is frequently taken instead to supply the stem of the third principal part.

When a verb wants any one or more of the principal parts, it evidently wants also the tenses formed from it or them; as *timeo*, *timui*, ——, *timēre*, to fear, to be afraid; *ferio*, ——, ——, *ferere*, to strike.

The participle of *past time* is wanting in the active voice. The defect is remedied by (1) the ablative absolute, or (2) by a relative clause, usually introduced by *quum.*

In the compound tenses of the indicative and subjunctive the participle is always in the nominative case, but may be used in both numbers and in all genders to suit the subject.

The participles in the compound infinitive are used in the nominative or accusative, of both numbers and of all genders; as *amātus esse*, *amāta esse*, *amātum esse*, *amātos esse*, *amātas esse*, &c.

Besides the forms *amātus sum*, I have been loved; *amātus eram*, I had been loved, &c., we find *amātus fui*, I have been

loved; *amātus fueram*, I had been loved, &c.; but in these cases the participle is to be regarded simply as an adjective.

Some tenses cannot be formed without the auxiliary verb *esse*, to be. These tenses are (1) in the active—the future infinitive, which consists of the participle future active with *esse;* and (2) in the passive—the perfect indicative and subjunctive, the pluperfect indicative and subjunctive, the future perfect, and the perfect infinitive, which consist of the perfect participle passive with parts of *esse.*

Periphrastic Conjugation.

The following periphrastic forms are frequently employed:—

(1) The future participle active is used with the verb *sum*, to express relations for which adequate expressions are not provided in the ordinary tenses of the verb. The signification of these periphrastic tenses is always that of the future. Thus—

Tense.		Indic.	Subjunc.	Indic. Subjunctive.	
Pres.	Scriptūrus	sum	sim	*I am, I may be*	*about to write.*
Imp.	Scriptūrus	ĕram	essem	*I was, I might be*	
Fut.	Scriptūrus	ĕro	—	*I shall be*	
Perf.	Scriptūrus	fŭi	fuĕrim	*I have been, may have been*	
Plup.	Scriptūrus	fŭĕram	fuissem	*I had been, should have been*	
F.Per.	Scriptūrus	fŭĕro	—	*I shall have been*	

Infin. { *Pres.* Scriptūrum esse, *to be about to write.* *Perf.* Scriptūrum fuisse, *to have been about to write.*

The passives of these forms cannot be made directly; but the same idea may be expressed by the phrase, *Futurum est, ut epistŏla scribātur;* or *In eo est, ut epistola scribatur.*

(2) The passive voice of transitive verbs is used in the future participle or gerundive, with the verb *sum*, to express what *ought to be done*, or *is to be done:* as—

Tense.		Indic.	Subjunc.	Indic. Subjunctive.	
Pres.	Amandus	sum	sim	*I am, I may be*	*to be loved.*
Imp.	Amandus	eram	essem	*I was, I might be*	
Fut.	Amandus	ero	—	*I shall be*	
Perf.	Amandus	fui	fuerim	*I have been, may have been*	
Plup.	Amandus	fueram	fuissem	*I had been, should have been*	
F.Per.	Amandus	fuēro	—	*I shall have been*	

Infin. { *Pres.* Amandum esse, *to be fit* (or *deserving*) *to be loved.* *Perf.* Amandum fuisse, *to have been fit* (or *deserving*) *to be loved.*

In these periphrases *fŭi* is occasionally used for *sum*, *fŭĕrō* for *ĕrō*, *fŭĕram* for *ĕram*, *fŭĕrim* for *sim*, *fŭissem* for *essem*, and *fŭisse* for *esse:* as *ămātŭs* (or *amandus*) *fŭi*, *fŭĕrō*, *fŭĕram*, *fŭĕrim*, *fŭissem*, *fŭissĕ*, &c.

VERBS (MORE OR LESS) IRREGULAR IN THEIR PERFECT AND SUPINE.

I.—The First Conjugation.

The regular terminational forms of the First Conjugation are *-āvi* and *-ātum*, like *ămo*, *ăm-āvī*, *ămāt-um*, *ăm-ārĕ*, to love.

The following verbs, however, have their perfects and supines, and the tenses derived from them, irregular in the way pointed out in the synoptical table given below:—

Crĕpo,[1]	crĕpui,	crĕpītum,	crĕpāre,	*to creak.*
Cŭbo,[2]	cŭbui *or* -avi,	cŭbĭtum,	cŭbāre,	*to lie.*
Do,[3]	dĕdi,	dătum,	dăre,	*to give.*
Dŏmo,	dŏmui,	dŏmĭtum,	dŏmāre,	*to tame.*
Frico,	frĭcui,	frĭcatum *or* frictum,	frĭcāre,	*to rub.*
Jŭvo,[4]	jūvi,	jūtum,	jŭvāre,	*to assist.*
Lăbo,	—	—	labāre,	*to fall.*
Lăvo,	lāvi,	lăvātum, lautum, *or* lotum,	lăvāre *and* lavĕre,	*to wash.*
Mĭco,[5]	mĭcui,	—	mĭcāre,	*to glitter.*
Nĕco,	necāvi *or* necui,	necātum,	necāre,	*to kill.*
Plĭco,[6]	plĭcui *or* plĭcāvi,	plĭcĭtum *or* plĭcātum,	plicāre,	*to plait.*
Pōto,	potāvi,	potātum *or* potum,	potāre,	*to drink.*
Præsto,	præstĭti,	præstĭtum *or* præstātum,	præstāre,	*to perform.*
Sĕco,[7]	sĕcui,	sectum,	sĕcāre,	*to cut.*
Sŏno,[8]	sŏnui,	sŏnĭtum,	sŏnāre,	*to sound.*
Sto,[9]	stĕti,	stătum,	stāre,	*to stand.*
Tŏno,	tŏnui,	tŏnĭtum,	tŏnāre,	*to thunder.*
Vĕto,	vĕtui *or* vetavi,	vĕtĭtum,	vĕtāre,	*to forbid.*

[1] Its compounds, *discrepo*, to differ, and *increpo*, to chide, have *-āvi* and *-ātum*, and also *-ui* and *-ĭtum.* The forms in *-avi*, *atum*, are the rarer ones.

[2] Those compounds of *cŭbo* which have *m* (e.g. *recumbo*) belong to the Third Conjugation; as *prōcumbo*, *procŭbui*, *procŭbĭtum*, *prōcumbere*, to lean forward; but those that have no *m* are conjugated like *cubo.*

[3] Most of the compounds of *do* belong to the Third Conjugation; as *addo*, *addidi*, *additum*, *addĕre;* but *circumdo*, to surround; *pessundo*, to ruin; *satisdo*, to give bail; and *venundo*, to sell, are of the First, and follow *do.*

[4] *Jŭvo* has for its future participle *juvāturus;* but *adjuvo* has *adjūturus.*

[5] *Emico*, to shine forth, has *emicui*, *emicatum;* but *dīmico*, to fight, *-avi* or *-ui.*

[6] The verb *plico* is rarely used in its simple form. The following compounds of it, namely, *duplico*, *multiplico*, *replico*, and *supplico*, have *-āvi*, *-ātum;* the others have both *-āvi*, *-ātum*, and *-ui*, *-ĭtum.*

[7] The future participle takes the full form *secātūrus.*

[8] *Sŏno* makes its future participle regularly, *sŏnātūrus.*

[9] Many compounds of *sto* make *stiti* and *stātum* (or *stĭtum*) in their perfect and supine. *Adsto*, *prosto*, and *resto* have no supine. *Antesto*, *circumsto*, *intersto*, and *supersto* have *stĕti* for the perfect, but no supine. *Disto* and *substo* want both perfect and supine.

II.—The Second Conjugation.

The normal terminational forms of the perfect and supine, in the Second Conjugation, are *-ēvi* and *-ētum;* as in *fleo*, *flēvi*, *flētum*, *flēre*, to weep. Verbs of this formation are few. The larger number resemble our model verb *moneo.*

The following irregular verbs in this conjugation are the most usual (classified):—

1. Perfect in *-ēvi;* Supine in *-ētum* (but two take *ĭtum*).

Abŏleo,	ăbŏlēvi,	ăbŏlĭtum,	ăbŏlēre,	*to abolish.*
Adŏleo *or* Adolesco,	adolēvi,	adultum,	—	*to grow up.*
Cieo,[1]	cīvi,	cĭtum,	ciēre,	*to stir.*
Compleo,	complēvi,	complētum,	complēre,	*to fill up.*
Delĕo,	dēlēvi,	dēlētum,	dēlēre,	*to blot out.*
Exŏleo *or* Exolesco,	exolēvi,	exolētum,	—	*to grow old.*
Neo,	nēvi,	nētum,	nēre,	*to spin.*
Obsoleo *or* Obsolesco,	obsolēvi,	obsolētum,	—	*to grow out of use.*
Vieo,	viēvi,	viētum,	viēre,	*to hoop a vessel.*

[1] Some of the compounds of *cieo* belong to the Fourth Conjugation; as *concio*, *concīvi*, *concītum*, *concīre.*

2. Perfect in *-ui;* Supine in *-tum* or *-sum.*

Censeo,	censui *or* census sum	censum *or* sensitum,	censēre,	*to value, think.*
Dŏceo,	dŏcui,	doctum,	dŏcēre,	*to teach.*
Misceo,	miscui,	mixtum *or* mistum,	miscēre,	*to mix.*
Sorbeo,	sorbui, sorpsi,	—	sorbēre,	*to suck up.*
Tĕneo,	tĕnui,	tentum,	tĕnēre,	*to hold.*
Torreo,	torrui,	tostum,	torrēre,	*to roast.*

3. Perfect in *-i;* Supine in *-sum.*

Frendeo,	frendi,	fressum,	frendēre,	*to gnash the teeth.*
Prandeo,[1]	prandi,	pransum,	prandēre,	*to breakfast.*
Sĕdeo,[2]	sēdi,	sessum,	sĕdēre,	*to sit.*
Strīdeo,	strīdi,	—	strīdēre,	*to creak, whistle.*
Vĭdeo,	vīdi,	vīsum,	vĭdēre,	*to see.*

[1] *Pransus* means having breakfasted; *impransus*, breakfastless, fasting.

[2] Many compounds of *sedeo* want the supine; as *desideo*, *dissideo*.

persīdeo, præsīdeo, resīdeo, and *subsīdeo.* When *sedeo* is compounded with prepositions of one syllable *e* becomes *i*, as *præsīdeo;* but when with those of two syllables it remains unchanged, as *circumsedeo.*

The following four reduplicate the first syllable in the perfect and its derived tenses:—

Mordeo,	mŏmordi,	morsum,	mordēre,	*to bite.*
Pendeo,	pĕpendi,	pensum,	pendēre,	*to hang.*
Spondeo,	spŏpondi,	sponsum,	spondēre,	*to promise.*
Tondeo,	tŏtondi,	tonsum,	tondēre,	*to shear.*

4. Perfect in *-i;* Supine in *-tum.*

Căveo,	cāvi,	cautum,	căvēre,	*to take care.*
Făveo,	fāvi,	fautum,	făvēre,	*to favour.*
Fŏveo,	fōvi,	fōtum,	fŏvēre,	*to cherish.*
Mŏveo,	mōvi,	mōtum,	mŏvēre,	*to move.*
Vŏveo,	vōvi,	vōtum,	vŏvēre,	*to vow.*

The following have no supine:—

Connīveo,	connīvi *or* connixi,	—	connīvēre,	*to wink.*
Ferveo,	fervi *or* ferbui,	—	fervēre,	*to boil.*
Păveo,	pāvi,	—	păvēre,	*to fear.*

5. Perfect in *-si;* Supine in *-tum* or *sum.*

Algeo,	alsi,	—	algēre,	*to be cold.*
Ardeo,	arsi,	arsum,	ardēre,	*to blaze.*
Augeo,	auxi,	auctum,	augēre,	*to increase.*
Frīgeo,	frixi,	—	frigēre,	*to be cold.*
Fulgeo,	fulsi,	—	fulgēre,	*to shine.*
Hæreo,	hæsi,	hæsum,	hærēre,	*to stick.*
Indulgeo,	indulsi,	indultum,	indulgēre,	*to indulge.*
Jŭbeo,	jussi,	jussum,	jŭbēre,	*to order.*
Lūceo,	luxi,	—	lūcēre,	*to shine.*
Lūgeo,	luxi,	—	lūgēre,	*to grieve.*
Măneo,	mansi,	mansum,	mănēre,	*to remain.*
Mulceo,	mulsi,	mulsum,	mulcēre,	*to stroke.*
Mulgeo,	mulsi,	mulsum *or* mulctum,	mulgēre,	*to milk.*
Rīdeo,	rīsi,	rīsum,	rīdēre,	*to laugh.*
Suādeo,	suāsi,	suāsum,	suādēre,	*to advise.*
Tergeo,	tersi,	tersum,	tergēre,	*to wipe.*
Torqueo,	torsi,	tortum,	torquēre,	*to twist.*
Turgeo,	tursi,	—	turgēre,	*to swell.*
Urgeo,	ursi,	—	urgēre,	*to press.*

6. Many verbs, chiefly intransitives, want the supine; as—

Arceo,	arcui,	—	arcēre,	*to keep off.*
Calleo,	callui,	—	callēre,	*to know.*
Egeo,	ĕgui,	—	ĕgēre,	*to want.*
Flōreo,	flōrui,	—	flōrēre,	*to flourish.*
Horreo,	horrui,	—	horrēre,	*to shudder.*
Lăteo,	lătui,	—	lătēre,	*to lie hid.*
Nĭteo,	nĭtui,	—	nĭtēre,	*to shine.*
Oleo,	ŏlui,	—	ŏlēre,	*to smell.*
Păteo,	pătui,	—	pătēre,	*to lie open.*
Rĭgeo,	rĭgui,	—	rĭgēre,	*to be stiff.*
Sĭleo,	sĭlui,	—	sĭlēre,	*to be silent.*
Stŭdeo,	stŭdui,	—	stŭdēre,	*to pay heed to.*
Tĭmeo,	tĭmui,	—	tĭmēre,	*to fear.*
Vĭgeo,	vĭgui,	—	vĭgēre,	*to thrive.*
Vĭreo,	vĭrui,	—	vĭrēre,	*to be green.*

7. Many intransitive verbs want both perfect and supine; but the infinitive of these verbs is regular.

Aveo, *to desire.*	Fœteo, *to stink.*	Mæreo, *to mourn.*
Calveo, *to be bald.*	Hĕbeo, *to be dull.*	Polleo, *to be powerful.*
Cāneo, *to be gray.*	Hūmeo, *to be damp.*	Rĕnīdeo, *to shine forth.*
Denseo, *to grow thick.*	Lacteo, *to grow milky.*	Scăteo, *to gush forth.*
Flāveo, *to be yellow.*	Līveo, *to be livid.*	Squāleo, *to be dirty.*

III.—THE THIRD CONJUGATION.

The regular conjugational forms of the perfect and supine are *-i, -tum,* or *-si, -tum;* as, *scrībo, scrips-i script-um, scrīb-ĕre,* to write. The irregularities are mainly the results of contraction and euphonic change, and are best classified as follows:—

I.—Labial Stems.

1. Perfect in *-si;* Supine in *-tum.*

Carpo,	carpsi,	carptum,	carpĕre,	*to pluck.*
Glūbo,[1]	glupsi,	gluptum,	glūbĕre,	*to strip.*
Nūbo,[1]	nupsi,	nuptum,	nūbĕre,	*to marry.*
Rēpo,	repsi,	reptum,	rēpĕre,	*to creep.*
Scalpo,	scalpsi,	scalptum,	scalpĕre,	*to scratch.*
Scrībo,[1]	scripsi,	scriptum,	scrībĕre,	*to write.*
Serpo,	serpsi,	serptum,	serpĕre,	*to crawl.*

[1] *B* is changed into *p* before *s* and *t*.

2. Perfect in *-ui;* Supine in *-tum* or *-ĭtum.*

Cumbo *or* Incumbo,	incŭbui,	incŭbĭtum,	incumbĕre,	*to lie upon.*
Strĕpo,	strĕpui,	strĕpĭtum,	strĕpĕre,	*to make a noise.*

3. Perfect in *-i;* Supine wanting or in *-tum.*

Bĭbo,	bĭbi,	bibitum,	bĭbĕre,	*to drink.*
Lambo,	lambi,	—	lambĕre,	*to lick.*
Rumpo,	rūpi,	ruptum,	rumpĕre,	*to burst.*
Scăbo,	scābi,	—	scăbĕre,	*to scratch.*

II.—Guttural Stems.

1. Perfect in *-si;* Supine in *-tum.* In these the *cs* and *gs*, which come together in the root and the termination, form *x*. *G* is changed into *c* before *t*.

Afflīgo,[1]	afflixi,	afflictum,	afflīgĕre,	*to strike down.*
Allĭcio,	allexi,	allectum,	allĭcĕre,	*to entice.*
Ango,	anxi,	—	angĕre,	*to vex.*
Aspĭcio,	aspexi,	aspectum,	aspĭcĕre,	*to behold.*
Cingo,	cinxi,	cinctum,	cingĕre,	*to surround.*
Cŏquo,	coxi,	coctum,	cŏquĕre,	*to cook.*
Dīco,	dixi,	dictum,	dīcĕre,	*to say.*
Dūco,	duxi,	ductum,	dūcĕre,	*to lead.*
Exstinguo,	exstinxi,	exstinctum,	exstinguĕre,	*to extinguish.*
Fingo,	finxi,	fictum,	fingĕre,	*to invent.*
Frīgo,	frixi,	frictum *or* frixum,	frīgĕre,	*to parch.*
Jungo,	junxi,	junctum,	jungĕre,	*to join.*
Lingo,	linxi,	linctum,	lingĕre,	*to lick.*
Mingo,	minxi,	mictum *or* minctum,	mingĕre,	*to make water.*
Mungo *or* Emungo,	ēmunxi,	ēmunctum,	ēmungĕre,	*to blow the nose.*
Pingo,	pinxi,	pictum,	pingĕre,	*to paint.*
Plango,	planxi,	planctum,	plangĕre,	*to strike.*
Rego,[2]	rexi,	rectum,	rĕgĕre,	*to direct, rule.*
Stringo,	strinxi,	strictum,	stringĕre,	*to grasp.*
Sūgo,	suxi,	suctum,	sūgĕre,	*to suck.*
Tĕgo,	texi,	tectum,	tĕgĕre,	*to cover.*
Tingo *or* Tinguo,	tinxi,	tinctum,	tingĕre *or* tinguĕre,	*to dip.*
Trăho,	traxi,	tractum,	trăhĕre,	*to drag.*
Ungo *or* Unguo,	unxi,	unctum,	ungĕre *or* unguĕre,	*to anoint.*
Vĕho,	vexi,	vectum,	vĕhĕre,	*to carry.*

[1] *Fligo*, to strike, is not used in the simple form. *Profligo* is a regular verb of the First Conjugation.

[2] *Surgo*, being a compound of *sur* and *rego*, has *surrexi, surrectum;* so *pergo*, from *per* and *rego*, has *perrexi, perrectum.* The other compounds of *rego* change *e* into *i*, as *erigo.*

2. Perfect in *-si;* Supine in *-sum* or *-xum.*

Fīgo,	fixi,	fixum,	fīgĕre,	*to fix.*
Flecto,	flexi,	flexum,	flectĕre,	*to bend.*
Mergo,	mersi,	mersum,	mergĕre,	*to sink.*
Necto,	nexi (-ui),	nexum,	nectĕre,	*to bind.*
Pecto,	pexi,	pexum,	pectĕre,	*to comb.*
Plecto,	plexi (-ui),	plexum,	plectĕre,	*to plait.*
Spargo,	sparsi,	sparsum,	spargĕre,	*to scatter.*
Tergo,	tersi,	tersum,	tergĕre,	*to wipe.*

3. Perfect in *-i* (with reduplication); Supine in *-sum* and *-tum*.

Disco,	dĭdĭci,	—	discĕre,	*to learn.*
Pango,[1]	pĕpĭgi *or* pēgi,	pactum,	pangĕre,	*to fix.*
Parco,	pĕperci *or* parsi,	parcĭtum *or* parsum,	parcĕre,	*to spare.*
Posco,	pŏposci,	—	poscĕre,	*to demand.*
Pungo,[2]	pŭpŭgi,	punctum,	pungĕre,	*to prick.*
Tango,[3]	tĕtĭgi,	tactum,	tangĕre,	*to touch.*

[1] The compounds take *i;* as *compingo, compēgi, compactum, compingere*, to fix together. The form *pango, panxi, panctum, pangĕre*, means to fasten, or drive in.

[2] *Compungo* has *compunxi.*

[3] The compounds of *tango* take *i;* as *attingo.*

4. Perfect in *-i* (stem vowel lengthened); Supine in *-tum.*

Ago,[1]	ēgi,	actum,	ăgĕre,	*to do.*
Cōgo(conago),	coēgi,	coactum,	cōgĕre,	*to compel.*
Frango,[2]	frēgi,	fractum,	frangĕre,	*to break.*
Ico,	īci,	ictum,	īcĕre,	*to strike (a treaty).*
Lĕgo,[3]	lēgi,	lectum,	lĕgĕre,	*to choose.*
Linquo,	līqui,	lictum,	linquĕre,	*to leave.*
Vinco,	vīci,	victum,	vincĕre,	*to conquer.*

[1] All its compounds, except *perăgo* and *circumăgo*, take *i;* as *abīgo*, to drive away.

[2] The compounds of *frango* take *i;* as *perfringo.*

[3] *Lego* retains *e* in the following compounds:—*allego, perlego, prælego* and *relego;* but changes it into *i* in *collĭgo, delĭgo, ēlĭgo, sēlĭgo:* it varies from the simple verb in the perfect of *dīlĭgo*, to love; *intellĭgo*, to understand; and *neglĭgo*, to neglect, which take *x;* as *dīlĭgo, dilexi*, &c.

5. Perfect in *-ui;* Supine in *-tum.*

Texo,	texui,	textum,	texĕre,	*to weave.*

6. The stem of the following verbs ends in a guttural, which is omitted in the present of *fluo* and *struo*, and is represented by *v* in *vivo.*

Fluo,	fluxi,	fluxum *or* fluctum,	fluĕre,	*to flow.*
Struo,	struxi,	structum,	struĕre,	*to pile up.*
Vīvo,	vixi,	victum,	vīvĕre,	*to live.*

III.—Dental Stems.

1. Perfect in *-si;* Supine in *-sum.* *D* and *t* are omitted before *s*, or are assimilated to it.

Cēdo,	cessi,	cessum,	cēdĕre,	*to yield.*
Claudo,[1]	clausi,	clausum,	claudĕre,	*to shut.*
Dīvĭdo,	dīvīsi,	dīvīsum,	dīvĭdĕre,	*to divide.*
Lædo,[2]	læsi,	læsum,	lædĕre,	*to injure.*
Lūdo,	lūsi,	lūsum,	lūdĕre,	*to play.*
Mitto,	mīsi,	missum,	mittĕre,	*to send.*
Plaudo,[3]	plausi,	plausum,	plaudĕre,	*to clap the hands.*
Rādo,	rāsi,	rāsum,	rādĕre,	*to scrape.*
Rōdo,	rōsi,	rōsum,	rōdĕre,	*to gnaw.*
Trūdo,	trūsi,	trūsum,	trūdĕre,	*to thrust.*
Vādo,[4]	—	—	vādĕre,	*to go.*
Invādo,	invāsi,	invāsum,	invādĕre,	*to go against.*

[1] *Claudo* has *u* in its compounds, as *excludo;* but *circumclaudo* remains unchanged.

[2] Its compounds take *i;* as *collido.*

[3] *Plaudo* changes *au* into *o* in the compounds, as *explodo;* except in the cases of *applaudo* and *circumplaudo.*

[4] The compounds of *vado* have perfect and supine; as *evado, evasi, evasum, evadere.*

2. Perfect Reduplicated.

Cădo,[1]	cĕcĭdi,	cāsum,	cădĕre,	*to fall.*
Cædo,[2]	cĕcīdi,	cæsum,	cædĕre,	*to strike, to cut.*
Pendo,	pĕpendi,	pensum,	pendĕre,	*to weigh.*
Tendo,[3]	tĕtendi,	tensum *or* tentum,	tendĕre,	*to stretch.*
Tundo,[4]	tŭtŭdi,	tunsum *or* tūsum,	tundĕre,	*to beat.*

[1] The compounds of *cado* have no supine, with the exception of *incido, occĭdo*, to fall, and *recido*, which take *cāsum;* as *occido, occĭdi, occāsum*, &c.

[2] The compounds of *cædo* change *æ* into *ī;* as *occīdo*, to kill, *occīdi, occīsum, occīdere.*

[3] The compounds have the supine in *tentum*, except *extendo* and *ostendo*, which have both *tensum* and *tentum.*

[4] The compounds of *tundo* do not reduplicate; as *contundo, contŭdi, contūsum.*

Do in composition, meaning "to put."

Abdo,	abdĭdi,	abdĭtum,	abdĕre,	*to hide.*
Addo,	addĭdi,	addĭtum,	addĕre,	*to add.*
Condo,	condĭdi,	condĭtum,	condĕre,	*to found.*
Crēdo,	crēdĭdi,	crēdĭtum,	crēdĕre,	*to believe.*
Dēdo,	dēdĭdi,	dēdĭtum,	dēdĕre,	*to give up.*
Edo,	ēdĭdi,	ēdĭtum,	ēdĕre,	*to give forth.*
Indo,	indĭdi,	indĭtum,	indĕre,	*to put on.*
Perdo,	perdĭdi,	perdĭtum,	perdĕre,	*to ruin, to lose.*
Prōdo,	prōdĭdi,	prōdĭtum,	prōdĕre,	*to betray.*
Reddo,	reddĭdi,	reddĭtum,	reddĕre,	*to restore.*
Subdo,	subdĭdi,	subdĭtum,	subdĕre,	*to substitute.*
Trado,	trādĭdi,	trādĭtum,	trādĕre,	*to hand over.*
Vendo,	vendĭdi,	vendĭtum,	vendĕre,	*to sell.*

3. Perect in *-i;* Supine in *-sum.*

Accendo,	accendi,	accensum,	accendĕre,	*to set on fire.*
Cūdo,	cūdi,	cūsum,	cūdĕre,	*to hammer.*
Edo,[1]	ēdi,	ēsum,	ĕdĕre,	*to eat.*
Fendo,	—	—	—	*to strike.*
Dēfendo,	dēfendi,	dēfensum,	dēfendĕre,	*to defend.*
Offendo,	offendi,	offensum,	offendĕre,	*to assault.*
Findo,	fĭdi,	fissum,	findĕre,	*to cleave.*
Frendo,	—	fressum,	frendĕre,	*to gnash the teeth.*
Frendeo,	—	frēsum,		
Fundo,	fūdi,	fūsum,	fundĕre,	*to pour.*
Incendo,	incendi,	incensum,	incendĕre,	*to burn.*
Mando,	mandi,	mansum,	mandĕre,	*to chew.*
Pando,	pandi,	pansum *or* passum,	pandĕre,	*to spread.*
Prĕhendo,	prĕhendi,	prĕhensum,	prĕhendĕre,	*to grasp.*
Scando,[2]	scandi,	scansum,	scandĕre,	*to climb.*
Scindo,	scĭdi,	scissum,	scindĕre,	*to tear.*
Strīdo, Strīdeo,	strīdi,	—	strīdĕre,	*to creak.*
Verto,[3]	verti,	versum,	vertĕre,	*to turn.*

[1] *Comĕdo* has the supine *comēsum* or *comestum.*

[2] The compounds change *a* into *e*, as in *ascendo, ascendi, ascensum, descendo*, &c.

[3] Some of the compounds of *verto* are deponents; as *revertor, prævertor*, &c.

4. Miscellaneous Dental forms.

Fīdo,	fīsus sum,	—	fīdĕre,	*to trust.*
Mĕto,	messui,	messum,	mĕtĕre,	*to mow.*
Pĕto,	pĕtīvi,	pĕtītum,	pĕtĕre,	*to seek.*
Sīdo,	sēdi *or* sīdi,	—	sīdĕre,	*to sit down.*
Sisto,[1]	stĭti,	stătum,	sistĕre,	*to cause to stand.*
Sterto,	stertui,	—	stertĕre,	*to snore.*

[1] The compounds of *sisto* have the supine in *stĭtum;* as *subsisto, substĭtum.*

IV.—Stems ending in the Liquids L, M, N.

1. Perfect in *-ui;* Supine in *-ĭtum* or *-tum.*

Alo,	ălui,	ălĭtum *or* altum,	ălĕre,	*to nourish.*
Cŏlo,[1]	cŏlui,	cultum,	cŏlĕre,	*to till.*
Consŭlo,	consŭlui,	consultum,	consŭlĕre,	*to consult.*
Frĕmo,	frĕmui,	frĕmĭtum,	frĕmĕre,	*to roar.*
Gĕmo,	gĕmui,	gĕmĭtum,	gĕmĕre,	*to groan.*
Gigno,	gĕnui,	gĕnĭtum,	gignĕre,	*to produce.*
Mŏlo,	mŏlui,	mŏlĭtum,	mŏlĕre,	*to grind.*
Occŭlo,[1]	occŭlui,	occultum,	occŭlĕre,	*to conceal.*
Trĕmo,	trĕmui,	—	trĕmĕre,	*to tremble.*
Vŏmo,	vŏmui,	vŏmĭtum,	vŏmĕre,	*to vomit.*

[1] *Obcolo*, i.e. *occulo*, changes *o* into *u.*

2. Perfect Reduplicated.

Căno,[1]	cĕcĭni,	cantum,	cănĕre,	*to sing.*
Fallo,	fĕfelli,	falsum,	fallĕre,	*to deceive.*
Pello,[2]	pĕpŭli,	pulsum,	pellĕre,	*to drive.*

[1] The compounds *occino* (i.e. *obcano*), to sing against, has *occinui, occentum.*

[2] The compounds of *pello* do not reduplicate; as, *compello, compuli.*

3. Perfect in *-si;* Supine in *-tum.*

Cōmo,[1]	compsi,	comptum,	cōmĕre,	*to adorn.*
Dēmo,	dempsi,	demptum,	dēmĕre,	*to take away.*
Prōmo,	prompsi,	promptum,	prōmĕre,	*to take forth.*
Sūmo,	sumpsi,	sumptum,	sūmĕre,	*to take up.*
Temno,	tempsi,	temptum,	temnĕre,	*to despise.*
Contemno,	contempsi,	contemptum,	contemnĕre,	*to despise.*

[1] The four first verbs are compounded of *ĕmo*, with the prepositions *con, de, pro,* and *sub.*

4. Various Liquid Forms.

Antecello,[1]	antecellui,	—	antecellĕre,	*to excel.*
Emo,	ēmi,	emptum,	ĕmĕre,	*to buy* or *take*
Lino,	lēvi,	lĭtum,	lĭnĕre,	*to smear.*
Percello,[1]	percŭli,	perculsum,	percellĕre,	*to strike down.*
Prĕmo,[2]	pressi,	pressum,	prĕmĕre,	*to press.*
Psallo,	psalli,	—	psallĕre,	*to play on an instrument.*
Sĭno,	sīvi,	sĭtum,	sĭnĕre,	*to permit.*
Tollo,[3]	sustŭli,	sublātum,	tollĕre,	*to raise up.*
Vello,[4]	velli *or* vulsi,	vulsum,	vellĕre,	*to pluck.*

[1] All the compounds of the obsolete *cello*, except *percello*, want the supine.

[2] The compounds of *prĕmo* take *i;* as *opprĭmo.*

[3] *Attollo* and *extollo* have no proper perfect and supine, but borrow those of *affĕro* and *effĕro.*

[4] The compounds may take either form of the perfect; but those beginning with *de, di,* and *per* usually prefer the *velli* form.

V.—Stems ending in the Liquid R.

Cerno,[1]	crēvi,	crētum,	cernĕre,	*to divide.*
Curro,[2]	cŭcurri,	cursum,	currĕre,	*to run.*
Fĕro,	tŭli,	lātum,	ferre,	*to bear, carry*
Gĕro,	gessi,	gestum,	gĕrĕre,	*to carry.*
Quæro,	quæsīvi,	quæsītum,	quærĕre,	*to seek.*
Acquīro,	acquīsīvi,	acquīsītum,	acquīrĕre,	*to acquire.*
Sĕro,	sĕrui,	sertum,	sĕrĕre,	*to entwine.*
Sĕro,[3]	sēvi,	sătum,	sĕrĕre,	*to sow.*
Sperno,	sprēvi,	sprētum,	spernĕre,	*to despise.*
Sterno,[4]	strāvi,	strātum,	sternĕre,	*to strew.*
Tĕro,	trīvi,	trītum,	tĕrĕre,	*to rub.*
Uro,	ussi,	ustum,	ūrĕre,	*to burn.*
Verro,	verri,	versum,	verrĕre,	*to sweep.*

[1] The stem of *cerno, sperno,* and *sterno* is *cer, sper,* and *ster* respectively, the *n* in each case being the strengthening consonant. In the perfect and supine the vowel and the liquid of the stem change places, so that we have in these parts *cre-vi* and *spre-vi* instead of *cer-vi* and *sper-vi;* in *sterno* the *e* is, morever, changed into *a*, as *stra-vi, stra-tum.*

[2] Compounds of *curro* beginning with *circum, re, sub,* and *trans,* rarely reduplicate the perfect. The others sometimes do.

[3] The compounds have the supine in *ĭtum;* as *consero, consēvi, consĭtum.*

[4] *Consterno*, when meaning to alarm, is a regular verb of the First Conjugation; but when signifying to throw down follows the forms of *sterno*, thus—*constravi, constratum.*

VI.—Stems ending in S and X.

Arcesso,[1]	arcessīvi,	arcessītum,	arcessĕre,	*to send up.*
Căpesso,[1]	căpessīvi,	căpessītum,	căpessĕre,	*to take in hand.*
Făcesso,[1]	făcessīvi,	făcessītum,	făcessĕre,	*to make.*
Lăcesso,[1]	lăcessīvi,	lăcessītum,	lăcessĕre,	*to provoke.*
Pōno,	pŏsui,	pŏsĭtum,	pōnĕre,	*to place.*
Vīso,	vīsi,	—	vīsĕre,	*to visit.*

[1] *Arcesso* is formed from an obsolete verb, *arcio*, a compound of *cieo; căpesso*, from *căpio; făcesso*, from *făcio;* and *lăcesso*, from *lăcio.*

VII.—Stems ending in U or V.

Perfect in *i;* Supine in *-tum.*

Abnuo,	abnui,	—	abnuĕre,	*to refuse.*
Annuo,	annui,	—	annuĕre,	*to assent.*
Acuo,	ăcui,	ăcūtum,	ăcuĕre,	*to sharpen.*
Arguo,	argui,	argūtum,	arguĕre,	*to prove.*
Congruo,	congrui,	—	congruĕre,	*to agree.*
Exuo,	exui,	exūtum,	exuĕre,	*to put off.*
Imbuo,	imbui,	imbūtum,	imbuĕre,	*to soak.*
Induo,	indui,	indūtum,	induĕre,	*to put on.*
Lăvo,	lāvi,	lautum, lōtum, *or* lăvātum,	lăvĕre or lavāre,	*to wash.*
Luo,[1]	lui,	—	luĕre,	*to atone.*
Mĕtuo,	mĕtui,	—	mĕtuĕre,	*to fear.*
Mĭnuo,	mĭnui,	mĭnūtum,	mĭnuĕre,	*to lessen.*
Rŭo,[2]	rui,	ruitum *or* rūtum,	ruĕre,	*to rush.*
Solvo,	solvi,	sŏlūtum,	solvĕre,	*to loosen.*
Spuo,	spui,	spūtum,	spuĕre,	*to spit.*
Stătuo,	stătui,	stătūtum,	stătuĕre,	*to set up.*
Sternuo,	sternui,	—	sternuĕre,	*to sneeze.*
Suo,	sui,	sūtum,	suĕre,	*to sew.*
Trĭbuo,	trĭbui,	trĭbūtum,	trĭbuĕre,	*to distribute.*
Volvo,	volvi,	vŏlūtum,	volvĕre,	*to roll.*

[1] The compounds of *luo* have the supine in *-ūtum;* as *ablūtum*, from *abluo.*

[2] Most of the compounds of *ruo* have *-ūtum* in the supine, as *dirūtum;* but *corruo*, to fall together, and *irruo*, to rush against, want the supine.

*VIII.—Verbs ending in -SCO.**

Abŏlesco,[1]	ăbŏlēvi,	ăbŏlĭtum,	ăbŏlescĕre,	*to grow out of use.*
Adŏlesco,[1]	ădŏlēvi,	ădultum,	ădŏlescĕre,	*to grow up.*
Cŏălesco,[1]	cŏălui,	cŏălĭtum,	cŏălescĕre,	*to grow together.*
Concŭpisco,	concŭpīvi,	concŭpītum,	concŭpiscĕre,	*to desire.*
Convălesco,	convălui,	convălĭtum,	convălescĕre,	*to grow strong.*
Cresco,	crēvi,	crētum,	crescĕre,	*to grow.*
Exardesco,	exarsi,	exarsum,	exardescĕre,	*to take fire.*
Exŏlesco,	exŏlēvi,	exŏlĭtum,	exŏlescĕre,	*to grow old.*
Glisco,	—	—	gliscĕre,	*to swell.*
Hisco,	—	—	hiscĕre,	*to gape.*
Nosco,[2]	nōvi,	nōtum,	noscĕre,	*to know.*
Pasco,[3]	pāvi,	pastum,	pascĕre,	*to feed.*
Quiesco,	quiēvi,	quiētum,	quiescĕre,	*to become quiet.*
Rĕvīvisco,	revixi,	revictum,	reviviscĕre,	*to revive.*
Scisco,	scīvi,	scītum,	sciscĕre,	*to ordain.*
Suesco,	suēvi,	suētum,	suescĕre,	*to grow accustomed.*

[1] These three verbs are derived from the obsolete verb *oleo.*

[2] *Agnosco* and *cognosco* have, in the supine, *agnĭtum* and *cognĭtum.* The future participle of *nosco* is *noscĭturus.*

[3] *Compesco*, to feed together, restrain; and *dispesco*, to separate, have *compescui* and *dispescui* in the perfect, but want the supine.

The following verbs are inflected partly of the Third and partly of the Fourth Conjugations.

Căpio,[1]	cēpi,	captum,	căpĕre,	*to take.*
Cŭpio,	cŭpīvi,	cŭpītum,	cŭpĕre,	*to desire.*
Făcio,[1]	fēci,	factum,	făcĕre,	*to make.*
Fŏdio,	fōdi,	fossum,	fŏdĕre,	*to dig.*
Fŭgio,	fūgi,	fŭgĭtum,	fŭgĕre,	*to flee.*
Jăcio,[1]	jēci,	jactum,	jăcĕre,	*to throw.*
Părio,[2]	pĕpĕri,	partum,	părĕre,	*to bring forth.*
Quătio,	quassi,	quassum,	quătĕre,	*to shake.*
Răpio,[1]	răpui,	reptum,	răpĕre,	*to seize.*
Săpio,[1]	sapui,	—	săpĕre,	*to taste, to be wise.*

[1] The compounds of *capio, rapio, jacio,* and *sapio* change *a* into *i;* as *recipio, dirĭpio, abjicio, consipio.* When *facio* is compounded with a preposition it changes *a* into *i;* as *conficio:* when with any other part of speech it retains the *a;* as *calefacio.* Another class of compounds of *facio* end in *-fĭco* and *-fĭcor*, and belong to the First Conjugation; as *sacrĭfĭco*, to offer sacrifice.

[2] Some of the compounds of *pario* have *-ui* in the perfect; as *aperio, aperui, apertum, aperīre*, to open; also *operio*, to shut, of the Fourth Conjugation.

The foregoing verbs in *io*, viz. *capio, rapio, cupio, facio, fodio, fugio,* &c., and their compounds, belong to the Third Conjugation. In these the *i* of the stem of the present tense is omitted before a termination commencing with *i*. They retain the *i* only in those tenses where *r* does not follow, *i.e.* only in the imperfect indicative (which may not be contracted into *-ībam*), the future indicative, and the present subjunctive; but where either *r* or no letter follows

* Such verbs as those ending in *-sco* are called *inceptive* or *inchoative*, and denote the beginning of an action. Most of those derived from substantives and adjectives want the perfect and also the supine. When the perfect does occur it ends in *-ui;* as *mātūresco, mātūrui, maturescere*, to grow ripe.

they take *ĕ*, both in the active and passive voice: as *capio, capĕ, capĕrem, capĕre*. So in the passive, *cap-ior, -ĕris, -ĕrer*; and deponents, as *pat-ior, -ĕris, -ĕrer*.

IV.—THE FOURTH CONJUGATION.

The regular inflexion forms of the perfect and supine are *-īvi* and *-ītum*; as *audio, audīvi, audītum, audīre*, to hear. The few verbs which follow are, however, irregular.

Amicio,	amicui *or* amixi,	amictum,	amicīre,	*to clothe.*
Apĕrio,	ăpĕrui,	ăpertum,	ăpĕrīre,	*to open.*
Eo,	īvi,	ĭtum,	īre,	*to go.*
Farcio,[1]	farsi,	fartum,	farcīre,	*to cram.*
Fulcio,	fulsi,	fultum,	fulcīre,	*to prop.*
Haurio,	hausi,	haustum,	haurīre,	*to draw* (water).
Opĕrio,	ŏpĕrui,	ŏpertum,	ŏperīre,	*to cover.*
Raucio,	rausi,	rausum,	raucīre,	*to be hoarse.*
Sæpio,	sæpsi,	sæptum,	sæpīre,	*to fence in.*
Sălio,[2]	sălui *or* sălii,	saltum,	sălīre,	*to leap.*
Sancio,	sanxi,	sancītum *or* sanctum,	sancīre,	*to ratify.*
Sarcio,	sarsi,	sartum,	sarcīre,	*to mend.*
Sentio,	sensi,	sensum,	sentīre,	*to feel, to think.*
Sĕpĕlio,	sĕpĕlīvi,	sĕpultum,	sĕpĕlīre,	*to bury.*
Singulto.	singultīvi,	singultum,	singultīre,	*to sob.*
Vēneo,	vēnii,	—	vēnīre,	*to be sold.*
Vĕnio,	vēni,	ventum,	vĕnīre,	*to come.*
Vincio,	vinxi,	vinctum,	vincīre,	*to bind.*

[1] The compounds take *e*; as *refercio, refersi, refertum*.

[2] The compounds of *salio* take *-ui* or *-ii* (for *-ivi*) in the perfect; as *insilio, insilui* or *insilii, insultum, insilīre*.

EXERCISE.

(1) Write out a paradigm of the First Conjugation, using for each tense of each mood a different verb, as they are arranged in the list of irregular verbs (p. 517).

(2) Write out three paradigms of the Second Conjugation, using for the tenses and moods the verbs in classes 1 and 2, 3 and 4, 5 and 6 (pp. 517, 518).

(3) Write out five paradigms of the Third Conjugation, using verbs having (1) labial stems, (2) guttural stems, (3) dental stems, (4) liquid stems, and (5) reduplicating in the perfect.

(4) Write out a paradigm of the Fourth Conjugation, using for each tense of each mood different verbs, as these are arranged in the list of irregular verbs.

Reading.—Before reading the sentences which follow, the student may be informed of these two grammatical facts, viz.:—

(1) When two or more substantives name, describe, or refer to the same thing, they agree in case, *i.e.* they are each put in the same case, and are said to be in *apposition*, *e.g.* Homerus poeta—the poet Homer.

(2) When two or more substantives come together not naming, referring to, or describing the same thing, the one which signifies source, origin, possession, &c., of the other is put in the genitive case, *e.g.* Fabula poetæ—the story of a poet; Horti Cæsaris—the gardens of Cæsar, or Cæsar's gardens, &c.

1. Scientia rerum bonarum et malarum est prudentia. 2. Thebæ, urbs validissima, Bœotiæ caput est. 3. Galliæ una pars continetur finibus Belgarum. 4. Undique, natura loci, Helvetii continentur. 5. Copia frumenti suppĕtit. 6. Extremum oppidum Allobrogum est Geneva. 7. In hoc monte latuerat aper miræ magnitudinis.

1. The knowledge of things good and evil is prudence. 2. Thebes, a very strong city, is the capital of Bœotia. 3. One part of Gallia is bounded by the territories of the Belgæ. 4. On every side, by the nature of the place, the Helvetii are hemmed in. 5. Abundance of corn is laid up in store. 6. The furthest town of the Allobroges is Geneva. 7. On this mountain there had lurked a boar of wondrous size.

EXERCISE.

In the foregoing sentences mark the leading apposite noun with a capital A, and its correspondent with a small *a*, and each genitive with a capital G.

(1) Underline the subjects in the following sentences, and note the agreement with the subjects (when required) in gender, number, and person of the other words referring to them:—

1. Britannia est patria nostra. 2. Incolæ insularum agricolæ sunt. 3. Hominum corpora mortalia sunt, animi immortales. 4. Magistrorum opera discipulis utilia sunt. 5. Nemo casu est philosophus. 6. Amicus verus thesaurus est magnus. 7. Helena causa fuit belli Trojani. 8. Vita hominis sine literis mors est. 9. Omnium malorum stultitia est mater. 10. Deus solus potest esse architectus et rector cœli et terræ. 11. Juno erat Jovis soror et conjux. 12. Non formosus erat, sed erat facundus Ulysses.

1. Britain is our fatherland. 2. The inhabitants of the islands are husbandmen. 3. The bodies of men are mortal, [their] souls immortal. 4. The works of masters are useful to their scholars. 5. No one is by chance a philosopher. 6. A true friend is a great treasure. 7. Helen was the cause of the Trojan war. 8. Man's life without culture is death. 9. Folly is the mother (cause) of every evil. 10. God alone can be the framer and governor of heaven and earth. 11. Juno was the sister and wife of Jupiter. 12. Ulysses was not handsome, but he was eloquent.

(2) Collect from the foregoing sentences instances (1) of the agreement of nouns and adjectives, (2) the government of one noun in the genitive by another, and (3) of nouns signifying the same thing agreeing in case.

(3) Arrange the nouns according to their declensions.

(4) Similarly arrange the adjectives, and decline together through both numbers and all cases three nouns with their agreeing adjectives.

(5) Where possible, alter the tenses of the verbs from present into *past* and *future*.

(6) Arrange the sentences in tabular form thus:—

Adjectives.	Nouns.	Verbs.	Adjectives.	Nouns.
Mortalia	hominum corpora	sunt	immortales	animi
Verus	amicus	est	magnus	thesaurus
Utilia	opera magistrorum	sunt		discipulis

PHYSIOLOGY.—CHAPTER VII.

DIGESTION—FOOD AND FOOD STUFFS—THE ORGANS, PROCESSES, AND ACCESSORIES OF ALIMENTATION.

Digestion is the process by which food is converted into nutriment. Food is required for specific purposes: (1) to replace the continual waste arising from the operation of the ordinary functions of the body, (2) to supply warmth, and (3) to supply power to be employed in labour, exercise, and thought. The alimentary apparatus of a plant, the root, is always in close contact with the nourishment it requires, and is constantly engaged in absorbing it for the supply of its wants. An animal is locomotive, and as it changes its place it must receive its alimentary supply into its body, and carry it wheresoever it goes, that it may be brought into and kept in constant contact with the alimentary apparatus.

The grand characteristic of animals is their possession of a stomach—*i.e.* a central membranous cavity into which food may be received, in which it may be operated upon, and prepared for being taken up into the circulation, and so distributed all over the system. The stomach and intestines constitute the digestive apparatus proper, but several other organs which co-operate in various ways to aid it constitute assistant factors in digestion. Besides, we have a set of organs for preparing the food for the stomach, tearing, bruising, and grinding it, and mixing it with fluid, that it may be easily swallowed and digested. It will be found most convenient, though perhaps it is not most philosophical, to trace the processes of digestion successively from the reception of the food by the mouth onwards. We will therefore commence with the jaws, mouth, and teeth; examine the salivary glands, the palate, and the gullet; inquire into the nature of the action of swallowing, and trace the food in its passage to the stomach. From the stomach we will observe it proceed into the small intestines, see how the bile and the pancreatic juice mingle with it, and learn how the nourishing parts of it are absorbed and carried into the circulating mass of the blood, while that part which is useless is expelled from the body.

Food cannot nourish the frame unless it be first changed, by chemical and vital conversion, into a fluid capable of being appropriated by and assimilated into the system. Animals differ from plants in their method of nutrition. The latter absorb the ultimate elements of their nourishment and transform them into food; but the former require their food to be, in the main, of organized not inorganic substances. Digestion is, in fact, the metamorphosis of organic structures into other definite elements capable of being employed in the building up of new bodily material. Food requires to possess, for animal nourishment, a certain amount of organic complexity; that is, it must have undergone a sort of natural preparation for readily entering into and forming part of that nutritional fluid which, as a renovating solution, is being constantly carried through the system—a permeating stream of revitalizing energy—in the blood. The elements of human food may be regarded as fivefold, viz. (1) *albuminoids*, albuminates, or protein compounds (as they are variously denominated).—Albuminous substances are seen in their types, the white of an egg and the serum of blood. Mulder gives as the ultimate proteic analysis of albumen—carbon, 55·48; hydrogen, 7·02; oxygen, 22·00; nitrogen, 15·55; phosphorus, 1·55; and sulphur, 0·40—total, 100·00. The special uses of albuminoids, as food, are the repair of the waste of the tissues of the body, the building up of the general frame, the furnishing of force for work, and the supplying of heat—though, for this latter purpose, they are more costly and less useful than other sorts of food. (2) *Carbo-hydrates* or *amyloids*.—Hydrates are compounds of water, as one of their proximate elements, and hydrates of carbon are compounds containing the same number of equivalents of oxygen and hydrogen as constitute water, together with a certain atomic weight of carbon. Gum, starch, and sugar are their ordinary type-forms. In the body they are changed into (and are often stored up as) fat. They largely aid in furnishing heat and providing work-power. (3) *Fats*.—These are compounds of carbon, hydrogen, and oxygen, in or about the following ratios:—Carbon, 79·0; hydrogen, 11·4; oxygen, 9·6—total, 100. Mutton suet and hog's lard may be taken as types. (4) *Water*.—Besides the water we drink—averaging in one form of fluid or another from 2 to 4 pints a day—there is a large quantity of water in what we eat. Good milk, speaking roundly, contains 80 per cent. of water; potatoes, 75; veal, 60; beef, 50; lamb and mutton, 45 to 50; bacon, 30. In point of fact, the greater part of the human body really consists of water. (5) *Salts*.—These are, chemically considered, combinations of acids with alkaline or salifiable bases. Sea-salt, or chloride of sodium is, of course, the ordinary form in which, as seasoning, these appear as adjuncts to food and aids to digestion. The proteids are mainly used as formers of the tissues of the body, though, as they form, by chemical metamorphosis within the body, amyloid compounds, they are also producers of warmth. They have sometimes been called essential food-stuffs, while the carbo-hydrates and fats have been classified as accessory food-materials, and the salts as requisite adjuncts. The purpose of the digestive apparatus is the reduction of these food-stuffs by minute subdivision or solution into such a state that they may be used in the building-up or the repairing of the body, and be separated from the innutritious material which accompanies them, so that it may be cast forth from the structures to which it is useless.

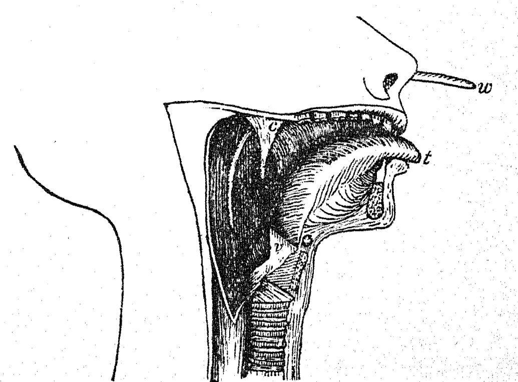
We cannot get, and even if we could we are unable (as we are constituted) to take advantageously as diet, the simple elements which form the chief constituents in wholesome food as well as in healthy bodies, such as carbon, hydrogen, nitrogen, oxygen, phosphorus, sulphur, chlorine, sodium, potassium, calcium, magnesium, iron, fluorine, &c. These materials are combined into organic preparations suitable for human food, and supplied in a state available for conversion into tissue and secretions, by the products of the vegetable and animal kingdom. Inorganic matter is elaborated and modified into organic matter in vegetables, and these undergo special processes, of more subtle elaboration still, in the system of various animals, for the purpose of being better fitted for being employed in the building-up and conservation of the exquisite tissues and wondrous organs of the human body. The process by which these food-stuffs are transformed into the material which is woven into the vital fabrics of the frame in the factory of life is digestion.

The laws relating to the nature, properties, and alimentary proportions and preparations of food are collected together, arranged, and explained under the title *Dietetics*. Here we require only to note that (1) human life cannot be supported for any great length of time upon food which is non-nitrogenous; (2) that it is only after having been brought under those subtle processes which constitute organic function that the proximate principles of food are so recombined and modified as to be fitted for human subsistence; (3) that a considerable mixture of diet is not only desirable, but essential; and (4) that whatever the apparent complexity and multifariousness of our food may be, its actually nutritive elements are few and simple, and, by the operations of the digestive processes, they are reduced to a distinct and definite simple condition which renders them suitable for assimilation with, and appropriation by, the vital energies of the human frame.

By the uneasy sensation of *hunger*, a safeguard against the body being permitted to wear out, we are solicited to take food. There is an unpleasant sensation produced by want of food, amounting at first only to a feeling of emptiness, lassitude, and indescribable uneasiness, but gradually getting worse until it ends in actual pain. Hunger, like thirst, is a call for what is necessary for the system, depending on the general state of the body. Natural hunger has always a reference to the wants of the general system.

Thirst is a sensation seated in the tongue, throat, gullet, and stomach. It depends on the state of the membrane which lines these parts, and of the fluids which naturally moisten it, and may arise either from a deficiency of fluid or from an acrid state of it. It appears to be a monitor calling for the dilution of the fluids of the body by drink, when the body has been exhausted by perspiration and fatigue, or when the contents of the stomach require to be made more fluid, that the necessary changes of digestion may be the more easily carried on. The feeling of extreme thirst is much harder to bear than that of hunger.

The *mouth* is the beginning of the alimentary canal. It is a hemispherical cavity, flat in the lower surface and convex



in the upper. Its roof is formed by a bony arch. It is shut in at the sides and front by the cheeks, lips, and lower jaw, while its floor is occupied by the densely interwoven muscular organ, the tongue. In the illustrative figure here shown, the right half of the lower jaw has been removed, bringing the bag of the pharynx into view. The *pharynx* is a conical bag which hangs down at the back part of the mouth, and leads into the gullet or œsophagus, marked *g*. The nose communicates with it from above, as is shown by a piece of whalebone *w*, passed through the nostrils into it. This arrangement enables us to breathe almost equally well by the nose or mouth; though sometimes, if we be taken by surprise with a fit of coughing while swallowing, the contents of the throat make their exit through the nose. To prevent this from occurring constantly, there is a curtain, the soft palate *c*, placed at the back of the mouth. We can see this on looking into a mirror. It rises or falls according to the necessity for its being applied either above or below. A long red tassel, the uvula, hangs down from

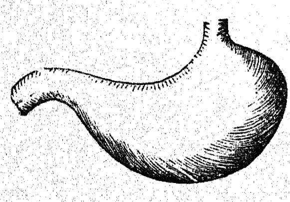
the centre of it, nearly touching the top of the tongue. It is endowed with great sensibility, and warns the curtain to rise whenever food comes into contact with it. When food is undergoing mastication, it is rolled about in the mouth and mixed with saliva, till it forms a kind of ball. This ball or *bolus* when it gets to the back of the mouth, between the arches of the palate, excites an irresistible tendency to swallow. The curtain then rises, so as to prevent any of the moist food passing up into the nose; the tongue rises against the roof of the mouth, to keep it from getting forward again; and thus the only course left for it is to pass down into the gullet, in doing which it pushes down the valve *v* of the windpipe. The food does not *fall* into the stomach—a man can swallow nearly as well when standing on his head as on his feet. This will be understood if we remember that the gullet is composed of a number of membranous rings. When one ring contracts, the food passes on into the next; then the second contracts, and squeezes it down into the third; while the first being still contracted, prevents it from getting up; and so the process goes on, regularly downward, until the food reaches the stomach. In vomiting an action precisely the reverse of this takes place—the food is *squeezed up* from the stomach into the mouth, although so rapidly that its passage seems almost instantaneous. The downward movement is *peristaltic*, the upward *anti-peristaltic*.

The *tongue* has a muscle originating in the back of the chin, and radiating through it forward, upward, and backward. By its aid we can protrude the tongue, turn it upward, downward, or to either side, render its surface convex, or make it hollow to serve for a conduit, as in drinking. Three pairs of muscles actually form the substance of the tongue; and not less than six pairs more aid in its motions. The whole inner surface of the mouth is lined with soft mucous membrane, which pours out a *mucus* from its surface to lubricate it, to protect it, and to assist the food to slide easily through it.

Six *glands* supply *saliva* to be mixed with the food. Two very large ones lie behind the ear, in the hollow between the lower jaw and the temporal bone, so that the motion of eating squeezes out their contents. Their *ducts* run forward in the cheek, and perforate the mouth opposite the second last tooth in the upper jaw, where, with the tongue, a small soft projection may be recognized. Two others lie on each side under the tongue, having a common duct, which may be seen opening on the fold of the membrane that bridles down the tongue. The tonsils lie just beyond the little tassel. They are of the size and shape of an almond, and secrete mucus from many little pits on its surface to moisten the throat.

The *teeth* are employed to cut and comminute the food. They are the hardest parts of the whole body. In the adult they are thirty-two in number, eight upon each side of each jaw. They are of four different kinds. In front there are, on each side, two incisors or cutting teeth, whose edges are like that of a chisel; next there is one eye-tooth, which is pointed; thirdly, there are two small grinders; and lastly, there are three large grinders. The teeth in the two jaws do not exactly meet; the cutting teeth of the upper jaw overlapping those of the under, while the grinders just face one another.

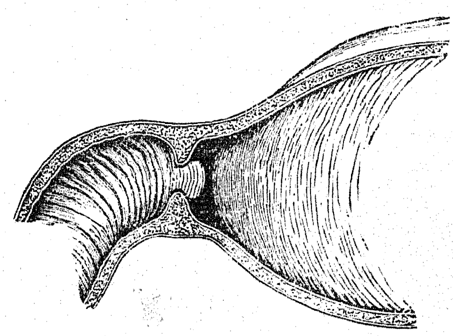
The passage of food through the pharynx and the gullet is accomplished very quickly and easily, the vermiculate motion operating in general with regular alternations of action. The œsophagus passes through the thorax, pierces the diaphragm, and after entering into the abdomen opens into the stomach at the cardiac orifice, which is situated on the side nearest the heart. When the extremity of the œsophagus contracts, it projects the food contained in it into the stomach, and the orifice, for the time being, closes.



The *stomach* is a bagpipe-shaped expansion of the alimentary canal, the large end of which is situated on the left side of the abdomen, immediately beneath the ribs and the diaphragm, while the small end underlies the liver at the hollow which is familiarly known as "the pit of the stomach." It is bent on account of its passing across the spine, the concave part being directed backwards and the convex forwards.

The parts of the stomach have received the following names:—(1) The lower, *i.e.* the outer hemispherical surface, the greater curvature; (2) the upper, hollow, dependent, baylike portion, the less curvature; (3) the left circling sweep, the cardiac extremity; and (4) the inner, right-hand, narrower portion, the pyloric extremity. The stomachic movements proceed from the cardiac gateway round the great curvature to the pyloric valve, and then across the less curvature towards the cardiac sweep, whence it is again, in a smaller circuit, remitted to the intestinal opening. This is done to secure an equal opportunity for the entire contents to be wrought upon and brought under the influence of the solvent juices of the stomachic cavity. See fig. 1, Plate XIII.

The coats or walls of the stomach are fourfold—(1) a tough outer fibrous-tissued coat, forming a strongly interwoven sack-like protective and inclosing investiture; (2) a coat of smooth powerful involuntary muscular fibre, constantly, under the excitement of food, contracting with a circuitous motion by which the fluid masses within are passed along in a systematic manner round the whole internal surface of the food-satchel, that it may be thoroughly emulsified, mixed, and reduced to a uniform cream-like pulp. The œsophagus enters the greater, splenic, or left side of the stomach, and the pylorus, which forms the outlet to the small intestines, has its place at the smaller or right end. These two orifices are upon the same level, so that the food cannot flow out of the stomach, but can get out of it only by pressure, arising from the contraction of its coats. These are muscular, as indeed are the coats of the whole intestinal canal. They are particularly strong at the smaller end, where they form a ring, which contracts so as completely to close the communi-



cation between the stomach and intestines. The stomach is lined with a velvety mucous membrane, similar to, and continuous with, that which lines the mouth and gullet. This membrane is full of minute bloodvessels, from which a mucous fluid is poured, which serves at once by mingling with the food to assist digestion, and to protect the coats of the stomach from injury. Accordingly, when any irritating substance is swallowed, a larger quantity of mucus than usual is immediately poured out, which envelops it and prevents, as far as possible, such evil consequences as might otherwise ensue. Besides this mucus another fluid is secreted in the stomach by its coats; it is called the *gastric juice*. This is a clear ropy fluid, of a saltish taste, possessing the power of dissolving all substances which are fit for food. It has no solvent effect, however, on the living stomach.

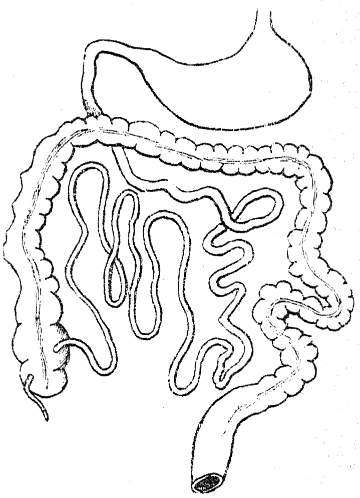
After a meal the stomach becomes agitated by a constant succession of graduated muscular contractions, which turn the food gently from the left side to the right, and back again, churning it and mixing it all well together, so that it acquires very much the appearance of gruel, the different aliments that have been swallowed becoming so blended as to form a homogeneous mass of a grayish colour. It is over and over again turned backward and forward for three hours or more, until the delicate sense which resides in the pyloric orifice is satisfied that it is in a fit state to be passed on. The constricted sphincter ring or pyloric valve then opens to let it proceed

and it passes into the intestinal canal. Such is the delicacy of perception with which this outlet of the stomach is endowed, that it will not suffer undigested food to pass until it has been rolled about in the stomach for many hours—presented to it again and again, and rejected many successive times. Indeed it often refuses to allow such food to pass at all, and then it must be summarily ejected by vomiting. It is in this organ that the first of these chemical changes takes place which fits the matter swallowed as food for being received into the fluids of the living body, and for becoming a component part of its tissues. The gastric juice acts on the triturated semifluid mass, gradually dissolves the digestible part, and, entering into union with it, produces a new, thick, turbid fluid, which bears the name of *chyme*.

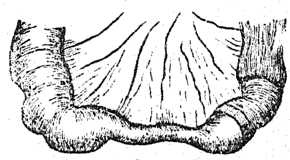
The *intestines* form a membranous tube nearly six times the length of the body, about five-sixths of this length belonging to the small intestines, and about one-sixth to the large. This membranous canal is convoluted into various folds, carefully packed, and effectively kept together by the duplicatures of the peritoneum, called the mesentery or inter-intestinal laminæ, by which the viscera are attached to the vertebræ, and the nerves and vessels of the lower digestive apparatus are supported. Although they really constitute one continuous tube, they are naturally divided into the smaller and the larger intestines, and for convenience' sake its various parts receive names denotive of their difference in figure, use, direction, &c. The first division of the smaller intestines is the *duodenum* (from its being about 12 inches in length). It receives the food-mass which has undergone stomachic digestion on its issue from the pyloric duct, and into it the contributions of the liver and the pancreas towards chymification—the bile and the pancreatic juice—are poured. The second portion is the *jejunum*—because, as the absorption of the nutritive portion of the food is principally effected in it, it is oftener found empty than the other parts; and the third portion, the *ileum*, which presents a folded appearance and is closed by the ileo-cæcal valve, which guards the gateway of the smaller into the larger intestines. Of the larger visceral tube, the first part is named the cæcum, a contracted expression for *caput cœcum coli*, "the blind head of the colon." It is the rounded end of the larger intestine. It lies on the right side of the abdominal cavity. The *ascending* colon passes upwards from it; then, as the *transverse* colon, making a sudden turn at a right angle, crosses to the left side of the body, where, bending backward and turning down, it proceeds as the *descending* colon along the left side, and is continued by the rectum. In fig. 1, Plate XIII., the whole course of the alimentary canal may be easily traced by attending to the explanatory lettering, and this reproduction of the appearance of the abdominal viscera will convey a more adequate idea than almost any amount of description expressed in any other than strictly technical language. The small intestines are the canals into which the chyme is received as it flows from the stomach; and, when digestion is completed, the large intestines serve chiefly as receptacles for the refuse which is intended to be expelled from the body.

In Plate XIII. there are shown some other typical stomachs —those of a sheep (figs. 2 and 3), and that of a fowl (fig. 4). Here we see four cavities:—1, the paunch (*rumen*), a large hollow at the cardiac (heart) end, into which the grass, &c., is thrust half chewed; 2, the honeycomb (*reticulum*), so called from its surface being dimpled with roughly hexagonal pits, which probably moisten the food delivered to it by the paunch. In the camel much water is retained in the extremely deep depressions of the second stomach, enabling the animal to exist in the desert, &c., for many days without drinking. From the *reticulum* the food is regurgitated into the mouth in a bolus, or cud, which the animal slowly chews until it is completely insalivated, when it is swallowed and passed, not into the paunch, but along a deep groove, the lips of which now close to form a tube leading into, 3, the *third* stomach, the manyplies (*psalterium* or *omasum*). The mucous membrane of the third stomach is arranged in thick longitudinal folds, so that a large surface is packed into small compass. After undergoing certain not well-ascertained changes in the psalterium, the food finally reaches, 4, the reed or rennet, the true stomach (*abomasum*), narrow and elongated, with a much more vascular mucous membrane, secreting the gastric juice, and fulfilling the function of true gastric digestion.

The function of mastication is performed in birds by the stomach, the gizzard receiving the stored and soaked contents of the crop, and grinding them between its powerful muscular walls with their dense horny epithelium, aided too by small stony particles, which the bird takes care to swallow from time to time. The dilatation of the tube before the gizzard, called the second stomach, provides the gastric juice in birds (see fig. 4).

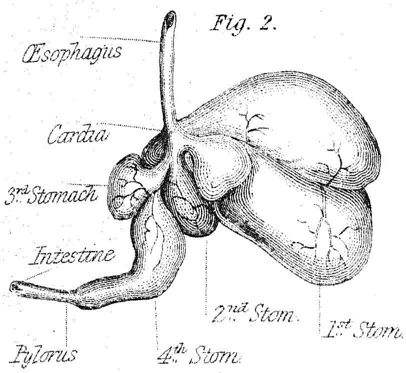


In the annexed diagram the small intestine of man is seen commencing from the smaller or right (*i.e.* the pyloric) end of the stomach, and passing to the right side. It lies close below the liver, and turning downward, receives from it the gall-duct, and from the *pancreas* the duct bringing its secretion, so that these fluids may mingle with the food; then, going across the spine to the left, it twists and forms a great number of convolutions which lie chiefly in the central parts of the abdomen, and finally terminate on the right flank in the large intestine. In the drawing, the convolutions are not represented exactly as they are in the living body, but as separated and spread out in order to render the plan of their turnings and twinings more distinct. The small intestine is not represented by more than half its proper length, otherwise the numerous convolutions would have made the whole figure quite confused. The entire intestine is lined with a continuation of the velvety membrane which coats the stomach, and is constantly moistened by a similar mucous secretion. The thickness of the bowel is formed of muscular fibres, arranged in two layers, as seen at the left end of the figure. The outer layer is longitudinal, and the inner circular. When these fibres contract, their effect is to narrow the bowel, as in the middle of the figure, and, at the same time, to draw upward to the contracted part the portion next further down, over the contained food, as one draws a stocking up over the foot that is pushed into it. The effect of the gradual and generally uniform contraction of these fibres, almost in the manner of a bunch of earthworms creeping through among one another, is to propel the food downward. The name of *vermicular* motion has been given to it owing to this resemblance. The gall-ducts enter the small intestine about 6 inches after it leaves the stomach; and the moment the bile mingles with the chyme a chemical change takes place, and the separation of the nutritious parts from the refuse begins. A creamy-looking white fluid appears on the surface of the food, next to the mucous membrane, and is sucked up by an infinity of small vessels called the *absorbents*. The obvious advantage of the great length of the alimentary canal is, that it affords opportunity for every part of the food to be turned about, and successively presented to the mouths of the absorbent vessels, so as to have its nourishing particles fully taken up and utilized. The matter in the intestinal canal therefore becomes gradually thicker and drier in its passage downwards.



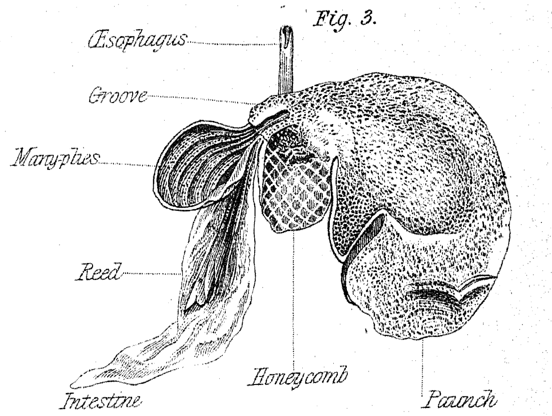
DIGESTION.

Fig. 2.



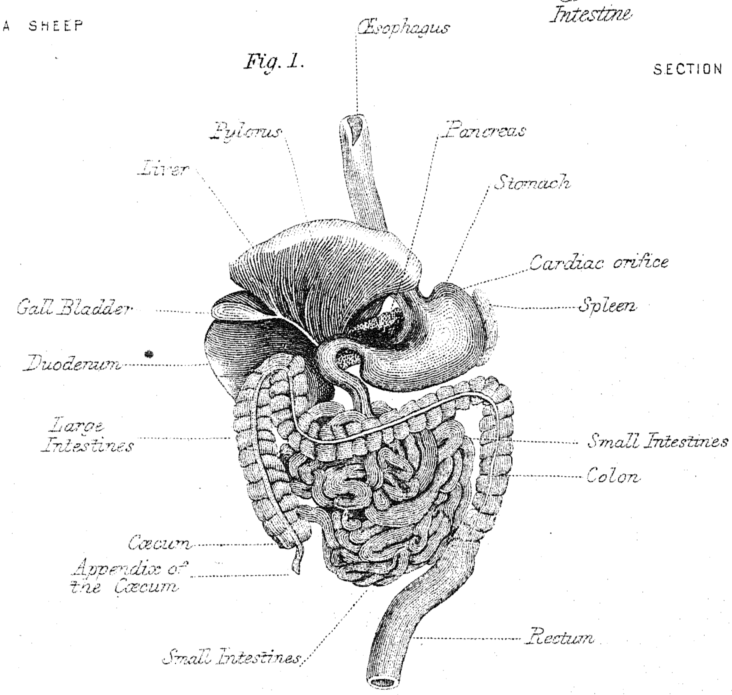
STOMACH OF A SHEEP

Fig. 3.



SECTION OF A SHEEP'S STOMACH

Fig. 1.



STOMACH & LIVER AND INTESTINAL CANAL OF MAN

Fig. 4.

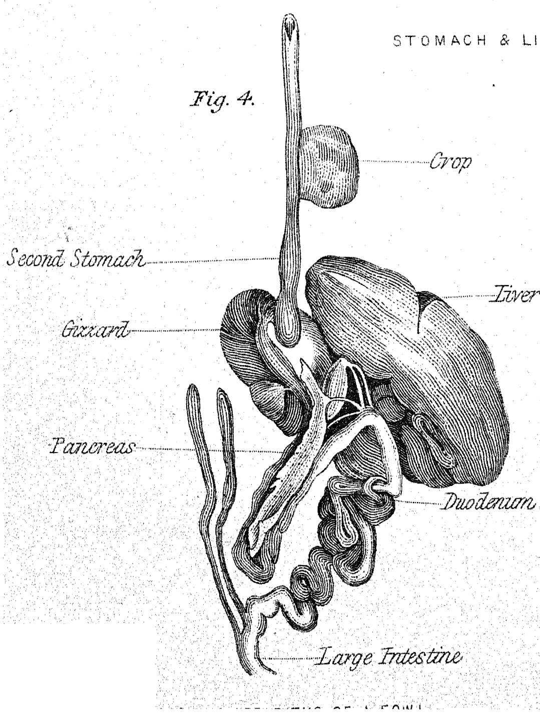
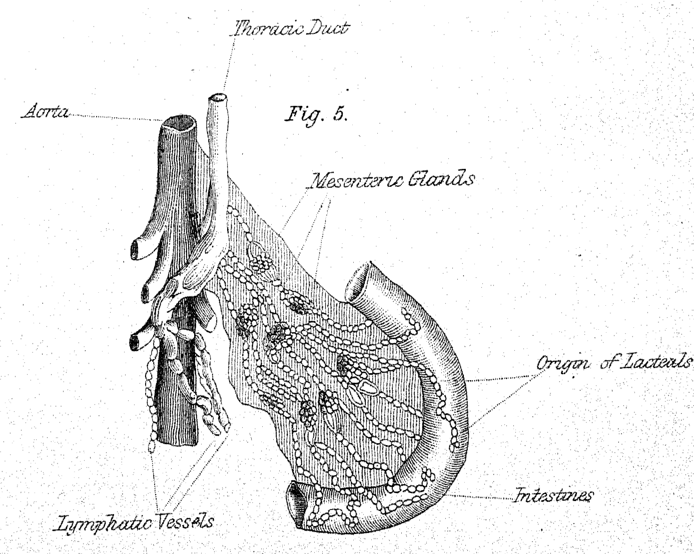


Fig. 5.



LACTEAL VESSELS.

and is stained of a yellow colour from the admixture of bile, &c., until it gets into the large intestines, where it puts on the character of *fæces*—effete or useless matter.

The large intestine is seen to commence by a blind end, into the side of which the small intestine opens. A valve is here placed to prevent the regurgitation of fæcal matter into the small bowels; and in this it always succeeds unless the force exerted to overcome it be very considerable. A curious appendage, about the size of a large earthworm, is seen hanging from the blind pouch at the end of the large intestine. From this blind pouch the ascending colon passes upwards on the right flank, crosses over the body, under the name of the transverse colon, just below the stomach, descends again in the left flank, forms a twist like the letter S, and then turns into the pelvis to open outwardly at the *anus*, the outward opening of the tube.

The nourishing part of the food, the *chyle*, is absorbed from the intestines by an infinity of small absorbent vessels, shown in fig. 5, Plate XIII. Their structure is very like that of veins, being provided with valves, which give them a knotted appearance, and which prevent the fluid they convey from taking a retrograde course. They are not more than the thirtieth of an inch in diameter, and are so transparent that they are not visible when empty. After a full meal these vessels are seen in great numbers, filled with a white milky fluid, whence they receive the name of *lacteals* (Lat. *lac*, milk). These vessels unite at the right side of the spine into a pipe about the size of a goosequill, which at length, by the thoracic duct, pours its contents, containing all the nourishment of the body (except the watery parts, which are taken up by the *lymphatics*) into the great vein of the upper part of the body, at the junction of the neck with the shoulder. This renewed fluid is poured, as we have said, into a vein, not into an artery, in order that it may be exposed to the air in the lungs, along with the current of the venous blood. This process completes its change into blood before it is circulated over the body.

The set of vessels which, from their absorption of lymph, are called *lymphatics*, are very difficult to discover, because the fluid which they convey is not milky, but transparent. The lymph is poured into the thoracic duct, and is mixed with the blood in the veins, so that afterwards both may be conveyed to the heart, be driven thence through the lungs, there to receive that supply of oxygen which shall transform the entire material into fresh and healthy blood. The lymphatics and lacteals are included under the common name of *absorbents*. Both pass through *glands*, which are roundish bodies about the size of hazel nuts, in which the absorbents subdivide and reunite, apparently for the purpose of mixing thoroughly the lymph and the chyle together before they pass into the thoracic duct. The thoracic duct is the main-trunk tube of the lymphatic system by which the limpid lymph and fluid chyle are conveyed into the circulation. It is from 18 to 20 inches in length, has its commencement in the abdomen opposite the second lumbar vertebra, and, passing through the diaphragm, rises through the chest to the neck, and joins the subclavian vein at an angle formed by its junction with the jugular vein.

The whole of the convolutions of the intestinal canal are covered with a thin shining membrane, called the *peritoneum*, which also lines the muscular walls of the abdomen. It is of the same nature as the membrane which lines the chest, covers the lungs, and surrounds the heart. Its smooth polished surface is evidently intended to permit the constant gentle motions of the bowels to go on easily, without our being at all sensible of them. This surface is kept moist by a thin liquid, called the peritoneal fluid, which occupies the interstices of the abdominal viscera, and fills up the entire cavity which the peritoneum lines. Thus all the spaces caused by the movement of the intestines, or by any alteration in the size or situation of their contents, are, as they occur, filled up, so that all the organs and contents of the abdomen are kept fitted exactly to one another, and packed with co-adaptive nicety. Indeed, it allows everything to lie in the smallest possible space, at the same time that it permits, on the slightest increase of pressure or bulk, such changes in space and place as may accommodate entering, moving, or emerging materials. It also supplies a fine gentle lubricant for those interstices which move upon each other, and provides a counter-pressure for that of the external atmosphere.

Tabular View of the Physiology of Food and Digestion.

The *Constituents* of Food-Stuffs are

I. Organic.			II. Inorganic.	
i. *Proteids*, or Albuminoids.	ii. *Carbo-hydrates*, or Amyloids.	iii. *Oleaginous matter*, or Fats.	i. *Water.*	ii. *Salts.*
1. Albumen.	1. Starch.	1. Lippyl.	1. Hydrogen.	1. Phosphorus.
2. Fibrin.	2. Sugar.	2. Stearine.	2. Oxygen.	2. Sulphur.
3. Syntonin.	3. Dextrin.	3. Margarine.	3. Carbonic acid.	3. Potassium.
4. Casein.	4. Gum.	4. Elein.	4. Ammoniacal salts.	4. Chloride of sodium.
5. Glutin.	5. Lactic acid.	5. Glycerin.	5. Sulphate of lime, &c.	5. Calcium.
6. Gelatin.	6. Acetic acid.	6. Cholesterin.		6. Magnesium.
7. Chondrin.				7. Fluorine.
Containing carbon, oxygen, hydrogen, and nitrogen.	Containing carbon, hydrogen, & oxygen.			

The *Processes* of Digestion are

1. Preliminary—	2. Essential—	3. Resultant—
(1) Prehension, reception of food.	(4) Deglutition, swallowing.	(7) Absorption, application to nutrition.
(2) Mastication, chewing.	(5) Chymification, or gastric digestion.	(8) Defecation, dismissal as useless.
(3) Insalivation, mulsifying.	(6) Chylification, or intestinal digestion.	

The *Organs* in Digestion are

1. The mouth, including teeth, tongue, salivary glands, soft palate, uvula, and epiglottis.	2. The pharynx, and 3. The œsophagus.	4. The stomach, including the *gastric follicles.*	5. The intestines, duodenum, jejunum, ileum, cæcum, colon, and rectum.	6. Auxiliaries, including liver, spleen, pancreas, gall-bladder, lymphatics, lacteals, and mesentery.

BOOK-KEEPING.—CHAPTER VI.

THE LEDGER—ITS RULING—ITS ENTRIES—AND HOW TO OPEN ACCOUNTS IN IT.

DR. SAMUEL JOHNSON long ago remarked that "the counting-house of an accomplished merchant is a school of method, where the great science may be learned of ranging particulars under generals, of bringing the different parts of a transaction together, and of showing, at one view, a long series of dealing and exchange." It is this method which enables any trader to regulate and control his business, however simple or intricate it may be, on principles at once intelligent and straightforward; and only by a proper knowledge and practical application of the scientific art of book-keeping is it possible —using another phrase of the Doctor's—"to preserve a multiplicity of affairs from inextricable confusion." Book-keeping is a historical record of such mercantile transactions revised and corrected. Of this, the Ledger may be regarded as the *memoria technica*—a classified key to the details of the business of which it is the record. It is an ever-ready, always at hand, and permanent statement of business details —the final depository and registration of every entry in a merchant's books.

Following the analytical method hitherto pursued in this series of instructions, in which an endeavour is made to supply a clear, exact, and easily understood statement of the nature, uses, peculiarities, and purposes of each book, prior to giving an exhibition of the whole all harmonized into systematic co-operation, we proceed to set forth, in descriptive detail and with examples, an account of this last and supreme book of the series employed in the methodical registration of mercantile accounts.

The Ledger (Italian *legāre*, to bind, tie, or pack up) is a counting-house book in which are contained classified accounts of all the articles dealt in by any given trader—under headings bearing the general name of property accounts—and of all the personal accounts which have been entered into by or with any trader, in the course of business, detailing the monetary results of the transactions which have taken place between the trader and those with whom he has dealt or who have dealt with him. The ordinary derivation ascribed to the title of this book is that it has its root from the Dutch *legger* or Middle English *liggen*, from Saxon *lecgan*, to lie, and that it indicates that this book is one which lies about the counting-house. We doubt much if, in point of fact, the Ledger of any merchant is allowed to lie about the counting-house, however much it may be in use, and the foregoing derivation seems to be much on a par with the jesting definition attributed to Sir Henry Wootton of a *leiger* or *resident* ambassador, as "one who lies abroad for his master." As the Ledger comes to us as part of the Italian system of book-keeping—though it probably reached us from the Netherlands—it appears more natural to seek the original of the name in the language of the inventors of the thing. Now the Ledger is the most important of all the business books. It contains an abstract of all the entries made in the other books. Its special characteristic is the methodic form in which the different accounts are presented. "The Day-book," as has been said, "bears a resemblance to a packsheet, which is taken to a fair whereinto the goods are put promiscuously, just as they come to hand." Following out the same analogy, we might compare the Ledger to a shop, in which, by a judicious arragement of shelves, boxes, and drawers, the same goods are assorted, marked at trade and selling prices, and arranged in regular order for sale, and to be duly accounted for either by their being in possession, or represented by money or the good credit of a known customer. It is this idea of classified and assorted packing, of arranged incorporation and combination, of systematic bringing and fastening together which *legāre* puts before us in the word Ledger—unless, indeed, we accept a simpler root of it, and deriving it from *léggere*, to read, we regard the Ledger as that book wherein the history of a business may be *read*. This derivation answers not only to the definition, but to the design of the Ledger, which is, as the principal book of account, that book in which a clear and distinct statement of all the business facts relative to any property or person with whom or regarding which any trade transactions have been carried on.

Two things specially require to be learned regarding the Ledger. The first and simplest is the form in which it is prepared—in other words, the manner in which it is *ruled*—*i.e.* arranged in columns and spaces. Of this the following short specimen may, for the present preliminary purpose, suffice:—

DR. BROAD CLOTH. CR.

1888.	Date.			F.	£	S.	D.
June	28	To Cash, 7*s.* per yd., 22 pieces,	352 yds.,	17	123	4	0
July	5	" Willis & Co., 3*s.* 4*d.* per yd.,	688 "	31	114	13	4
"	16	" G. Hardy, 3*s.* 8½*d.* per yd.,	520 "	24	96	8	4
"	27	" Kerr & Co., 9*s.* 2*d.* per yd.,	124 "	5	56	16	8
"	30	" Johns Bros., 8*s.* 3*d.* per yd.,	476 "	15	196	7	0
"	31	" Profit and Loss—gained, .	. . . .		126	1	2
					713	10	6

1888.	Date.			F.	£	S.	D.
July	1	By Sales, 10*s.* per yd., 12 pieces,	190 yds.,	16	95	0	0
"	3	" Sundry account, 10 pieces,	162 "	...	81	1	0
"	30	" Sales, 9*s.* 2*d.*,	238 "	27	109	0	8
"	"	" Sales, 10*s.*,	100 "	27	50	0	0
"	"	" Sundry account, 10*s.*,	138 "	...	69	0	0
"	"	" Sales, 4*s.*,	172 "	27	34	8	0
"	"	" Sundry account, 4*s.* 6*d.*,	172 "	...	38	14	0
"	31	" Sales, 4*s.* 6*d.*,	320 "	28	72	0	0
"		" Sundry account, 10*s.*,	24 "		12	0	0
"		" Sundries on hand, 344 at 3*s.* 4*d.*, 200 at 3*s.* 8½*d.*, 138 at 8*s.* 3*d.*,	. . . .		152	6	10
					713	10	6

The column-lines are usually executed by the paper-rulers, according to a pattern furnished either by the merchant himself or by his chief clerk, in the case of any peculiarity being required, and, when this is not the case, is found properly done in the ordinary mode of ledgers. The student should observe (1) that the accounts in the Ledger are arranged on the usual principle in all mercantile books—viz. with a Dr. and Cr. side. There is next, on each side, columns for the name of the month and the day of the month, a space for the specific entries, a small column for the folio of the Journal (or other book) from which the entries have been transferred, and lastly the usual money columns. These are, of course, added up and balanced at special periods in the manner shown above—where the difference between the Dr. and Cr. sides of each account in the Ledger is called the *balance* of that account, and is transferred ultimately to the balance sheet.

In some, especially retail, businesses the sides of each account in the Ledger contain a double set of money columns—one for extending, *i.e.* carrying out, the sums of the Dr., the other for extending the sums of the Cr. sides. Opening an account in the Ledger signifies technically, *i.e.* in the book-keeper's sense, to enter an accounts' title, for the first time, in the book. When this requires to be done, the title—whether of a property or of a personal account—is to be written in a bold legible style of handwriting at the head of the space [to be] allotted to the account, which is generally proportioned to its (estimated) importance. As each account in the Ledger ought not only to be easily seen and read, so it should also be able to be readily referred

to. Therefore, to every Ledger an *index* is attached, into which, as soon as any account has been opened in the Ledger, the title of that account requires to be entered in the alphabetic order of the first (or otherwise the most important) letter of the title, together with the number of the page in which the account has been "opened." The several entries belonging to that account are then transferred from the Day-book, Journal, or other book in which the transaction to be recorded appears, as they arise. This bringing of each entry into its proper place, under its appropriate heading or title in the Ledger, is technically called *posting*, of which more shall be said hereafter.

If it should happen that any account fills up the page (or space in a page) allotted to it when "opened," the summation of each side should be made and noted at the foot, the title should then be written out on a new page (or part of a page), the number of that page should be inserted in the index, and on the Dr. side of the fresh account should be written—To amount brought forward from folio [giving the number of the page from which it is transferred] *so much;* and on the Cr. side—By amount brought forward from folio [giving, as before, previous pagination and summation found thereon].

GEOMETRY.—CHAPTER VI.

THE AXIOM REGARDING PARALLEL LINES—THE COGENCY OF CONVERSE PROPOSITIONS.

Converse propositions are not necessarily true. They require to be demonstrated to be trustworthy. Euclid always proves the truth of any converse proposition he employs. He has laid down this statement as an *axiom*—the *twelfth*—"If a straight line meet two straight lines, so as to make the two interior angles on the same side of it, taken together, less than two right angles, these straight lines, being continually produced, shall at length meet on that side on which are the angles which are less than two right angles." An axiom is a fundamental truth beyond which the mind cannot reach, and which it is compelled to accept and rely upon as a principle which must be assumed in reasoning. It cannot be proved because it is, if the terms of it are understood, simple, self-evident, and seen intuitively to be true It is not easy to regard Euclid's axiom as clear, comprehensible, and free from difficulty. It requires to be explained that it may be intelligently accepted by the mind. A straight line is length conceived of as proceeding in undeviating sameness of direction. Two straight lines which are such that, however far they proceed, they can never meet, can in no part of their course ever come nearer to each other, for if they did approach one another they must ultimately meet. Leslie, who regards Euclid as having "endeavoured to evade the difficulty [of defining parallel straight lines] by styling the fundamental proposition an axiom," provides in his Book I. Proposition 24, a proof that "parallel lines are equidistant [from one another], and [that] equidistant straight lines are parallel." This is what Euclid really meant by his axiom, "that two straight lines meeting in a point cannot *both* be parallel to one and the same third straight line"—their characteristic being that they have no inclination towards one another.

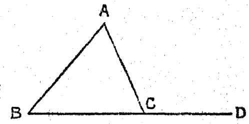
It is as a foundation for what he has to prove regarding parallel lines that Euclid requires the twelfth axiom, and the seventeenth proposition is given by Euclid to safeguard and define his axiom, and to show us exactly how much we require, in that axiom, to assume as true. Almost all geometrical theorems really arrange themselves into quaternions or groups of four: (1) the theorem itself, (2) its opposite or contradictory, (3) the converse of the original theorem, and (4) the converse of its opposite. Now it has been found by the most observant reasoners that if a proposition and its converse are both proved to be true, the contrary proposition is necessarily true as well. Hence, Euclid indirectly proves his axiom by proving that if two straight lines which are cut by a third do meet, the two interior angles are less than two right angles; for in proving this he proves the contrary proposition, that if two straight lines which are cut by a third do *not* meet, the two interior angles are *not* less than two right angles, which again yields its converse—if two straight lines which are cut by a third make the two interior angles less than two right angles, these lines, if produced far enough, do meet, and that, of course, as the axiom puts it, on the side on which those angles are which are less than two right angles.

Euclid having in the previous theorem made partial progress towards the demonstration of the interesting, important, and most useful theorem presented in Proposition 32—a theorem which enters into almost every geometrical investigation and many of those scientific inquiries which are based on geometric truth—saw an important corollary to that theorem which gratified him; and though it seemingly interrupts the systematic sequence of his Elements, he carefully sets down this landmark in the theory of parallels as

Proposition XVII.

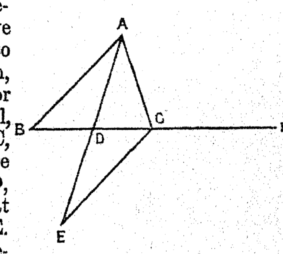
Any two angles of a triangle are together less than two right angles.

Let A B C be a[ny] triangle; any two of its angles together [*i.e.* the sum of any two of its angles] shall be less than two right angles. Produce any side of it, say B C, to D. Then (I. 16) A C D is the exterior angle of the triangle ABC, and it is greater than the interior and opposite angle A B C. To each of these angles add the angle A C B. Then the angles A C D, A C B, are greater (Axiom 4) than the angles A B C, A C B. But A C D, A C B are together (I. 13) equal to two right angles; and hence A B C, A C B are together less than two right angles. In the same manner it may be proved of any other two angles of the triangle A B C, that they are together less than two right angles. Q.E.D.



The student should construct and work out fully the proof of the theorem in regard to the other two angles—extending A C, say to a point E, A B to a point F, and so on.

Here is another form of demonstration. Bisect B C in D. Join A D and produce it to E, so as to make A D and D E equal; then join C E. Because A B D, E C D, have their sides A D, D B, equal to D E, D C, by construction, and their included (vertical or opposite) angles (I. 15) equal, therefore the two angles A B C, A C B, taken together, are equal to the two angles E C D, A C B, taken together; that is, to the whole angle A C E. But this angle A C E—because any single angle of a triangle is less than two right angles (I. 13 and 14)—is less than two right angles. Therefore, the angles A B C, A C B, which are equal to it, are less than two right angles. The same may be shown regarding the remaining angles. Therefore, any two angles, &c. Q.E.D.



From this proposition it is manifest: (1) that the angles at the base of an isosceles triangle must be acute angles, and (2) that if one angle of a triangle is right or obtuse, the other angles must be acute. It could, besides, be demonstrated from this that any two external angles of a triangle not vertically opposite to each other, must be together greater than two right angles.

We can now also take a further step towards the proof of Euclid's twelfth axiom by showing its contrary more clearly—namely, that *if a straight line, meeting two other straight lines, makes the two interior angles on the same side of it not less than two right angles, these lines shall never meet on that side if produced ever so far.*

For, if it be possible, let two straight lines meet which make with another straight line the two interior angles on the same side not less than two right angles; then it would follow that these three straight lines formed a triangle, two angles of which are not less than two right angles—which we have just shown in the foregoing proposition is absurd and impossible.

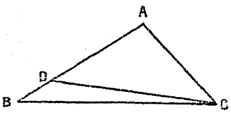
It would also follow from this theorem that *two straight lines, which are both perpendicular to the same straight line, are parallel to each other.*

The eighteenth and nineteenth propositions are the converse one of the other. They should be studied in connection with the fifth and sixth, the reasoning of which they follow, and the truths contained in which they extend and complete. The former is direct in its demonstration, the latter is indirect. Care requires to be taken not to confuse the one with the other.

Proposition XVIII.

The greater side of every triangle is opposite to the greater angle [i.e. has the greater angle opposite to it].

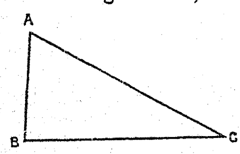
Let A B C be a triangle of which the side A B is greater than the side A C; then the angle A C B shall be greater than the angle A B C. The side A B is greater, by hypothesis, than the side A C. Make A D equal to A C. Join C D. Being the angles at the base of an isosceles triangle (I. 5), A D C is equal to A C D. But as the side B D of the triangle C D B is produced to A, the exterior angle A D C is greater (I. 16) than the interior and opposite angle D B C or A B C. Therefore the angle A C D, and much more the angle A C B, is greater than A B C. Therefore the greater side, &c. Q.E.D.



Proposition XIX.

The greater angle of every triangle is subtended by the greater side (i.e. has the greater side opposite to it).

Let A B C be a triangle of which the angle A B C is greater than the angle B C A, then A C is greater than A B. For, if A C is not greater than A B, it must either be (1) equal to, or (2) less than it. If A C is equal to A B, then the angle A B C is equal (I. 5) to the angle A C B; but by the hypothesis it is not equal, and therefore A C is not equal to A B. If, on the other hand, A C were less than A B, then the angle A B C (I. 18) would be less than the angle A C B; but it is not less. A C has been shown to be (1) not equal to A B, and (2) not less than A B, and therefore it must be greater than A B. Therefore the greater angle, &c. Q.E.D.

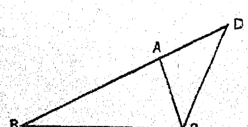


We now know in regard to every triangle, that—according as its two sides are equal or unequal—so the angles subtended by these sides are also equal or unequal, and that where the sides are unequal the greater angle is that which is opposite the greater side, and *vice versâ*. The case of equal sides and angles was taken up by Propositions 5 and 6; that of unequal sides and angles has just been dealt with in Propositions 18 and 19. We now proceed to

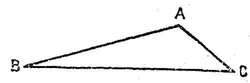
Proposition XX.

Any two sides of a triangle are together greater than the third side.

Let A B C be a triangle, then any two sides of it shall be together greater than the remaining [*i.e.* the third] side, viz., (1) A B+A C greater than B C, (2) A B+B C greater than A C, and (3) B C + C A greater than A B. Produce any side, say B C to D, make C D equal to B C, and join D A. C D equals B C by construction, therefore the angle A D C equals A C D (I. 5); but B D C is greater than A C D (Axiom 9) and also greater than A D C, and hence in the triangle D B C the angle B C D is greater (I. 19) than the angle B D C; therefore B D is greater than B C. But D B equals, by construction, both B A and A C, and therefore B A and A C are together greater than B C. In the same way it may be demonstrated that, A B, B C, are greater than C A, and that B C, C A are greater than A B. Therefore any two sides, &c. Q.E.D.



The student would do well to work out the other cases so as to complete the demonstration, and after that he may be ready to admire and accept the simple proof suggested by J. M. Wilson, viz., "In any triangle A B C, B C is the straight line joining B and C; it is therefore shorter than the broken line B A C;" that is, the two sides B A, A C, are together greater than B C. It may be deduced as a corollary that the difference of any two sides of a triangle is less than the third side, and after a little consideration the student may see reason for concluding that one side of any polygon [*i.e.* multiangular figure] must be less than the sum of all the other sides.

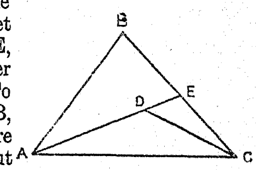


We have two other points to understand in the theory of triangles before we are able to say we have observed and reasoned out all their palpable phenomena. One which is, in part, really a corollary from Proposition 20, comes before us as

Proposition XXI.

If from the ends of the side of a triangle there be drawn two straight lines to a point within the triangle, these shall be less than the other two sides of the triangle, but shall contain a greater angle.

Let A B C be a triangle, and let the straight lines A D and C D, from the extremities of the base A C, be produced to a point D within that triangle; then these two straight lines, while less than the sides A B and C B of the triangle A B C, yet contain a greater angle than A B C. Produce A D to meet C B in E, the two sides A B, B E, of the triangle A B E are greater than the third A E (I. 20). To each of these add E C; then A B, B E, E C [*i.e.* A B and B C] are greater than A E and E C. But the sides C E and E D of the triangle D E C are (I. 20) greater than D C. Consequently C E, E D, together with D A [*i.e.* C E and E A] are greater than C D and D A. Wherefore the sides A B and B C being greater than A E and E C—which are greater than A D and D C—must be still greater than A D and D C; that is, the lines A D and D C are less than A B and B C, the sides of the triangle. But again—



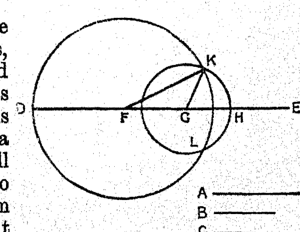
The angle A B C is the exterior angle of the triangle D E C, and is therefore greater (I. 16). For the same reason the angle D E C is greater than A B E—the opposite interior angle of the triangle A B E. A D C is consequently greater still than A B E or A B C. Therefore if from the ends, &c. Q. E. D

Power to do is in Euclid's view the consummate proof of thorough knowing. He therefore presents to us this problem in the construction of triangles as

Proposition XXII.

To make a triangle of which the sides shall be equal to three given straight lines (each to each), but any two whatever of these three lines must be greater than the third.

Let A, B, and C be the three given straight lines, in which the condition laid down in the proposition has been duly observed, it is required to construct a triangle whose sides shall be equal (each to each) to these three lines. From a point, D, draw a straight line, unlimited, towards E. According to Proposition 3, cut off D F equal to A, F G equal to B, and G H equal to C. With F as the centre, and radius F D, describe the circle D K L; then with centre G,



and radius G H, describe the circle H K L, cutting the former circle in K. Join K F and K G, and then the triangle K F G has its three sides equal to the three straight lines A, B, and C. Because F is the centre of the circle D K L, F D equals F K, and F D equals A; therefore F K equals A. Similarly, because G is the centre of the circle L K H, G H equals G K, and G H equals C; therefore G K equals C. F G, by construction, equals B, and hence the three sides of the triangle K F G are equal (each to each) to the three given straight lines. Q.E.F.

If the student will try to work the problem when the sum of any two of the given straight lines is (1) equal to, and (2) less than, the third side, he will soon see the necessity for the restrictive *proviso* which Euclid introduces into the proposition. Without attention to that the problem would not be among the things which could be *done*.

BOTANY.—CHAPTER VI.

FLOWERS—PLANT-REPRODUCTION—CRYPTOGAMIA—PHANEROGAMIA—INFLORESCENCE.

FLOWERS, whether they appear in field, glen, woodland, hillslope, pasture, or garden, excite admiration and attract attention. They are a joy, and may be made a gladsome study. The loveliness of their forms and colours, the deliciousness of their odours, and the profusion in which they present themselves to the eye, combine to charm and elicit curiosity. Plant-life is not altogether given for grace and ornament, or as an embellishment added to nature as a gratifying finishing touch. Vegetation converts the mineral materials of the earth into living structures, which again supply nourishment to the animal creation, and both prepare, for human use, food rich in the elements required to build up and conserve the wonderful tissues of man's frame. Plants are life-giving blessings to us, and flowers by their beauty induce investigation into the nature, purposes, and uses of those vegetable products of which they constitute the crowning grace. Flowers are the illuminated characters in which nature has written out for us the alphabet of botany. They are concentrated storehouses of life, and in them are wrapped up the best energies of a plant's being, as well as the fresh blessedness of scientific instruction and poetic inspiration. All living things have, as Cuvier said, "an origin in generation, a growth by nutrition, and a termination by death." To come into being, to grow, and to depart hence are the common characteristic facts of the history of living organisms. The mortality of the individual, yet the perpetuity of the race, requires that the parent forms should possess reproductive powers such as should enable them, under given conditions, to leave successors to themselves. Flowers consist, morphologically, of leaves which have been arrested in their growth and modified for a special purpose, in form and colour. The type-form of vegetable growth is foliar: (1) cotyledonous or seed-leaved, (2) foliage-leaved, (3) bracteal-leaved, forming cupules, involucres, paleæ, and glumes, and (4) floral-leaved. The flower is the form in which the consummation of the reproductive power is, in the higher types of plant-life, signalized. It contains the apparatus which originates the seed, and, in the minutest core of it, the elementary seed lies in ante-natal rudimentariness, as in a satin-soft cradle, till the moment of maturity arrives. So plants are naturally multiplied and increased.

But plants may be multiplied in many ways—by budding, grafting, inarching; by layers, pipings, cuttings; by suckers, by division of roots and tubers, as well as by seed. There are few species of plants from which, by some of these modes, multiplication cannot be accomplished. Such plants as produce separate individuals from detached parts are called proliferous (Lat. *proles*, offspring; and *fero*, to bear). The flowering currant and the gooseberry (Ribes) generate, to a certain extent, by propagation. A number of garden flowers, as the carnations (*Dianthus caryophyllus*), are usually reproduced by slips, with successful results. Common thyme (*Thymus vulgaris*), when it would fail, is continued in healthy vigour by superimposing soil on its absorbent extremities. Budding takes place in cauline incisions, or on the edges and in the axil of leaves, as in *Bryophyllum calycinum*, *Malaxis paludosa*, and several species of Gesneria, Gloxinia, and Achimenes, &c. Separable buds assume independent growth by roots, in Alliums, Trifoliums, and others, as well as in the Alpine grasses, Festuca, Aira, Poa, &c. It has been observed, however, that the roots of such plants differ in direction from those of seeds, by a tendency to develop in the line of the trunk.

Reproduction by division is natural to many plants, as sugar-cane, by its stem; strawberry, by runners; and potatoes, by tubers; but in the majority of cases in which shoots are propagated the intervention of a voluntary agent is required. Besides, all these species are furnished with true seeds for their natural increase. Multiplication by artificial means is therefore a phenomenon supernumerary in its character. It does not enact reproduction, but simple continuation, a difference worthy of being particularly observed. The rationale, however, does not lessen its marvel. Nature perpetuates the world of plants by an agency neither partial nor contingent. The forms of individual life made efficient by propagation originate in the dynamizing influence of cells, that specific power by which an original vesicle enlarges and conforms its interior atoms to its own pattern. In reproduction, on the other hand, a different plan is pursued; a confluence of germ and sperm being required, two cells exert a mutual effect on each other, so as to give rise to an entire and distinct body.

Among the simpler forms of plants reproduction is carried on by the instrumentality of spheroids, usually called sporules or spores (Gr. *spora*, a seed), and sometimes thecæ (Gr. *theke*, a sac). Of this sort are the Algæ, Fungi, and Lichens, the Mosses, Lycopodii, and Ferns. In the Algæ, &c., the spores are destitute of a proper covering or receptacle, and, for the most part, are merely diffused through the tissues of the plant; but in the mosses, &c., they appear in a somewhat elaborated form, by being invested or encased. The spores of these plants seem to become productive by the contact of two cells of different kinds; and by those who are inclined to pursue the idea of fructification, the one cell, containing granular matter, is called *Antheridium*, and the other, containing germinating matter, *Pistilidium*. It is not, however, agreed among botanists that the spores owe their formation to the co-agency of sex. Each reproductive cell contains variously-coloured points, called endochrome (Gr. *endon*, within; and *chroma*, colour); and one envelops others, so as to become a *sporangium* (Gr. *spora* and *aggos*, a vase or vessel), that is, a spore-case, while the vital spores are included within its cavity. The sporangia are furnished with two or more marginal filaments, or vibratile cilia, by means of which, when discharged from Algæ, they are enabled to move about in the fluid juices of the plant, or in the sea. But after germination has taken place these are absorbed. In mosses the sporangia are supported on stalks or setæ (Lat. *seta*, a bristle); in short, they exhibit various modifications. In Confervæ there is a conjugation of cells, in which the contents of the one pass, by the formation of a tube, into the others. In Diatomaceæ the germinating bodies are placed on the outside of the cells.

These forms of plant-life belong to the *cryptogamic* (Gr. *chruptos*, concealed; and *gamos*, union) departments of the vegetable kingdom. Another state of things, however, presents itself to view in the *phanerogamic* (Gr. *phaneros*, apparent; and *gamos*) species. Every one has become familiar, in the course of a rural walk, with those brilliant creations which peer up in the grass and perfume the air, the gentle flowers, some in buds wrapped up in tunics, and others blushing in naked loveliness. These possess instruments for fertilizing the germ of the future plant. On the outside of each organism is arranged a series of leaves, within which rises a central filament or stem, and around the stamina capped with tops of prolific dust. This apparatus may be conveniently arranged under blossoms, fruit, and seed. The headings under which these specific parts of plants are respectively treated are termed inflorescence, fructification, and embryology.

In phanerogamous (*i.e.* flower-bearing) plants the entire flower is to be considered as the reproductive portion of the

plant. Its physiological function is to secure the continuation of its species by the production of seed—the containing material of a new life. Every part and detail of the flower, whether of structure, form, colour, &c., is adapted to effect this definite aim. Each plant has an economy of its own, and is plastic (1) in the building up of its structure, (2) in the storage and use of such materials as are required for its individual existence, and (3) in the perfecting of the means by which new plants similar to itself may take its place in the treasury of nature. A study of the manner in which the flowers of various plants are arranged shows that a definite plan governs the flowerage of each species of plants, though a general type-form underlies them all. A flower, in the botanist's ideal, usually consists of four parts, of which the first two—the calyx and the corolla—in general have the characteristics of being the protective and attractive parts, and are called the *floral envelopes;* while the other two, the stamens and pistils, constitute the *essential organs*, and are the effective and reproductive parts, *i.e.* the parts essential to the natural multiplication of plants similar to that on which the flower is found. In the absence of the last-named two, no collection of leaves, however beautifully coloured and harmoniously arranged they may be, is botanically regarded as a *flower*. The manner in which flowers are arranged on the stems or branches of a plant is called *inflorescence* or *anthotaxis*.

The inflorescence in its collective state may be traced with a reference to (1) the formative leaf which ushers it, (2) the stalk prolonged, (3) the bud which becomes developed, and (4) the envelopes which expand upon it.

1. The axil of leaves supplies the place of formation to the buds of flowers as well as the buds of branches; but the preliminary leaf of the flower, *i.e.* any leafy organ situated on the floral axis below the flower, takes the name of *bractea*, *bract*, or pre-floral leaf. Inflorescence in which bracts occur is denominated *bracteated;* where bracts are wanting it is termed *ebracteated.* The flower may be separated from the flower bud by a flower stalk, or it may be closely applied to it, if sessile. In either case the position of the bract is at the base, and if intermediate bracts occur they are properly termed *bracteoles* or *bractlets.* In general appearance, *bracts* differ somewhat from the ordinary leaves of plants; in several instances, as in *Calla æthiopica*, they are enriched with colouring, and in respect to their attachment many are persistent, though the greater number are deciduous. They assume the shape of mere scales, or threads, or tufts of hair, in the Crucifera, in some species of sage, lavender, and crown-imperial, and in this form they are called *coma* or *squamæ.* It is these scales which cover the fertile flowers of the willow; they likewise form the cupula or cup of the acorn, and the paleæ or white scales of the artichoke. In grasses the outer scales or husk are commonly designated *gluma*, *glumes.* Where a whorl of bracts exists, as in *Daucus carota*, it is *general involucre*, and if divided into a smaller whorl it is *partial involucre* or *involucel.* When one or more flowers are inclosed by a sheathing bract, the case is named a *spatha* or *spathe*, as in Snowdrop and Narcissus (Plate VII., fig. 1); and when several spathes of smaller size occur, they are termed *spathellæ.*

2. The stem of flowers exhibits them either at its apex, as in little gentianella, or springing from the points in which leaves join the main stem, as in scarlet pimpernel, or again, branching from the supports which are there produced, as in Biting stonecrop. The general axis—that is, the first stalk of a flower, whether single or clustered—is called *primary*, and by emphasis the rachis (Gr. *rhachis*, spine). If there be a *secondary* or derived stem immediately supporting the flower, it is the *peduncle* (Lat. *pes*, foot); and if any subordinate stem, again, arises from the last, it is *tertiary* or *pedicel.* The terms pedunculate and pedicellate, in reference to a flower, consequently express the relation of the branch on which it is produced. Where a stalk is wanting, the flower, of course, is sessile. Among the various forms assumed by the peduncle, *i.e.* the flower-stalk, we may mention (1) that of the single, as in the primrose (*Primula vulgaris*); (2) subdivided, as in London pride (*Saxifraga umbrosa*); flattened, as in cockscomb (*Celosia cristata*); spiral, as in the aquatic *Valisneria spiralis;* and spiny, as in the Mudwort (*Alyssum spinosum*). It also occurs cylindrical and grooved.

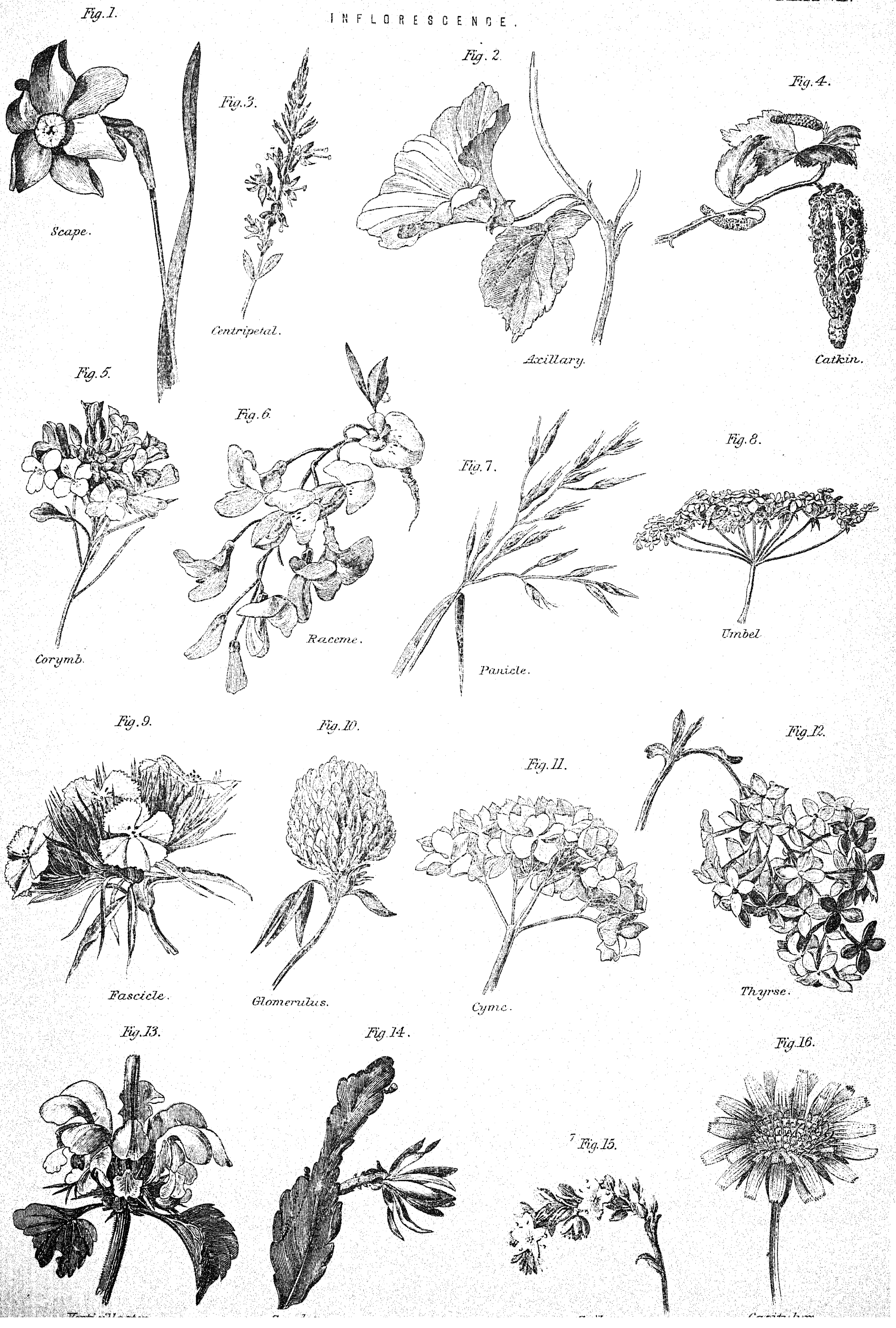
There are two modes of inflorescence peculiar to the arrangement of the axis now mentioned. The growth of the axis is sometimes terminated by the production of a flower on its anterior or upper extremity; but in other instances, as in Geranium, Rosa, and Geum, it is prolonged in a variety of ways beyond the first flower. The floral axis, therefore, may be found in practice either (1) bearing a single flower at the end of the stalk, and if there be more, always subsequently producing them lower down on the axis, then called *definite*, *determinate*, or *terminal* inflorescence, which develops itself centrifugally, from the top towards the bottom; or (2) if the axis continues to grow beyond the first flower, producing flowers from above, it is named *indefinite*, *indeterminate*, or *axillary* inflorescence, which expands its buds in centripetal order, that is, from the circumference inwards. In the one, the progress of formation is subject to various derangements; in the other, the parts are formed successively without interruption.

Of the *definite* mode, where a terminal flower occurs at the end of the axis, the common poppy (*Papaver rhœas*) may be referred to as an example. Numerous flowers may, however, be produced even on one or on separate axis, if their original direction—as in the gentian (*Erythrea centaurium*)—is from the same bract which develops the first buds, or from floral leaves placed below the central flower. As the central flower expands first, the expansion is centrifugal. But each branch may be stopped in its growth after producing a single flower; it then vegetates laterally, and these lateral branches are themselves stopped after forming one flower. This whole system receives the name of *cyme*, and *cymose* is the character applying to it, as in the elder tree. When the expansion takes place as in sweet-william, it is denominated *fascicle* (Plate VII., fig. 9); in such plants as the Labiatæ, *e.g.* dead-nettle (fig. 13) and wild marjoram, the clusters are called *verticillasters* (Lat. *verticillus*, a *verto*, a little whorl); while the curvations apparent in the borage-worts (Boraginaceæ), are named *helicoidal* (Gr. *helix*, a ring, and *eidos*, form) or *gyrate.*

The axis of a flower is *indefinite* when the flowers are developed from a succession of floral leaves springing upwards from those of the first flower. If, by a contraction of the axis, a broad plate or disc, termed a *receptacle*, be formed upon it, as in sea-pink, dandelion, &c., a *capitulum*, head, or tuft occurs (fig. 16); called also sometimes, according to the length of the pedicels, or the convexity and concavity of the receptacle defined, *calathium* (Gr. *kalathion*, a little basket), as in daisy (*Bellis perennis*); *glomerulus*, a ball, as in teasle or clover (Dipsacus, fig. 10); and *hypanthodium* (Gr. *hupo*, under, and *anthos*, flower), as in Contrayerva (Dorstenia). When several secondary axes arise from the flattened surface of the extremity, whether each ends in a single flower or repeats a radiation of flowers of nearly equal length, circled like an umbrella, it is an *umbel*, as in hemlock (fig. 8); and the allied plants, fennel, parsley, &c., are consequently named *umbelliferous.* *Corymbus*, *corymb* (fig. 5), approaches the mode of flowering of the umbel, but is distinguished by the unequal length of the footstalks, which proceed, not, as in the latter, from the same centre, but from different parts on both sides of the stalk. When nearly equal pedicels, terminating in single flowers, are given off at one point from the primary axis or peduncle, the result is the formation of a *raceme* or *cluster* (fig. 6), as in the currant, grape, or trefoil. If the peduncle diverges, the branching inflorescence becomes then a *panicle* (fig. 7), as in London pride, oats, &c. *Thyrsus* or *bunch* is a closer form of panicle, contracted into oval dimensions, as in lilac, &c. (fig. 12). But if the peduncle be really awanting, or from its shortness difficult of recognition, the sessile flowers, as in the ribworts (Plantago), form a *spica* or *spike* (fig. 15), which is further characterized by the following modifications:—When the spike is succulent and sheathed, either simply or branching, it is a *spadix* (fig. 14), as in palms; when bearing unisexual flowers, usually males, and suspended by an articulation, as in hazel, it is an *amentum* or *catkin* (fig. 4); and when producing only female flowers covered

BOTANY.

INFLORESCENCE.



with scales, it is either a *strobilus*, as in hop, or a *cone*, as in fir. Among the grasses, many florets arise in one calyx, and this arrangement, presenting small spikes, is called *spiculæ*, spikelets, or *locustæ*, which either cluster on the rachis, or branch on a panicle.

Flowers in the bud may be described as fixed points surrounded by rudimentary modified leaves. They differ from leaf buds in the central point being fixed instead of growing. Sometimes this central point departs from its fixed character, and by continuing its growth assumes the form of a branch, with leaves but little differing from the ordinary leaves of the plant. Such a growth is an unnatural one, and is generally characterized as a monstrosity.

The development of the leaf-bud is called *vernation;* but *alabastrus* (rose-bud), is the general term used for the flower-bud. The period of its spreading is called *anthesis* (Gr., flower-opening) ; and the manner in which the floral envelopes are arranged in the bud receives the title of *æstivation* (Lat. *æstivus*, pertaining to summer), or *prefloration* (Lat. *pre*, before, and *flos*, flower).

If the bud be carefully removed, we find that the summit of the axis on which it was fixed manifests certain forms incipient of it. There then meets the view, a nearly horizontal disc, on which the whorls or rotations of flowers are destined to be arranged. This receives the general appellation of *thalamus* (bridal chamber). It is full of minute organisms, exhibiting cellular papillæ in a ring form. The centre is occupied with the summit of the *receptacle*, to which all the parts of the bud are attached. The *torus* is situated between the calyx and pistil, and forms a common base for the corolla and androcæum. The *androcæum* (Gr. *aner*, male, and *oikion*, habitation) is the verticillar base of the stamens. *Nectaries* are glands which are generally produced by the torus, and situated immediately or depending on it.

Supposing the bud to be on its axis we indicate its general relations. Taken as a whole, it supplies the means of exhibiting its arrangements. When the parts of a whorl are of nearly uniform height, and disposed in a circle, the following characters apply: (1) the *æstivation* is *valvate* when they adjoin by their edges, as in the mallow; (2) if the edges at the points of junction be turned inwards, as in buglos (Lycopsis) it is *induplicate;* (3) if outwards, as in spurge (Euphorbia), *reduplicate;* and when in a circular whorl, as in oleander and carnation, the parts overlap each other, it is (4) *contorted;* but when, by a difference of level in the parts of verticils, each part spirally covers a portion of another, the æstivation is (5) *imbricated*, as in the dog-rose ; when the parts cover each other completely, it is (6) *convolute;* and when the imbrication is such, that out of a whorl of five parts two are external, two internal, and the remaining one covering and covered by the others in turn, it is (7) *quincunxial*, resulting in the way in which five is arranged on a dice-die; (8) *alternate*, when the inner whorl alternates with the outer; (9) *plicative*, when folded or plated together; (10) *vexillary*, a common form of æstivation in papilionaceous plants. The different forms of æstivation are each permanent in the species in which they are found, and are of some importance in systematic botany.

The *verticils* are further characterized as they regard each other. The different series of leaves composing a flower are not only arranged on a principle of alternation, but are mutually symmetrical in point of number. The most general numbers which prevail are either 5 and 4, or some multiple of them, in dicotyledonous and exogenous plants; 3, or its multiples in monocotyledons and endogens; and 2 and 4, or their multiples, in acotyledons and acrogens. Thus, if a calyx consists of 5 parts, the alternating corolla usually has 5 also; the stamens 5, 10, 20, &c., and the pistil 5, or some multiple of 5. And so with the rest of the numbers.

The following tabular forms may serve to place the foregoing matter more distinctly before the memory of the botanical student.

THE LEAVES OF PLANTS ARE—

(1) Seed-leaves (cotyledons).
(2) Foliage.
(3) Bracts—arranging themselves in
  (i.) cupules, (ii.) involucres,
  (iii.) paleæ, (iv.) glumes,
  (v.) spathes.

(4) Floral.

Enveloping.		Essential.	
1. Calyx.	2. Corolla.	3. Stamens.	4. Pistils.
the parts of which are respectively			
i. Sepals.	ii. Petals.	iii*a*. Filament, *b* anther.	iv. Carpels.

INFLORESCENCE IS—

I. Definite or Determinate.
1. Solitary *terminal* flowers.
2. Cymes.
  a Uniparous, *b* biparous.
  i. Helicoid ; ii. scorpoid.
  (1) Elongated, (2) contracted.
3. Compound (as in some calceolarias).

II. Indefinite or Indeterminate.
1. Solitary *axillary* flowers.
2. Grouped.
  a Pedicellate, *b* sessile.
  (1) Elongated, (2) contracted.
3. Compound, having
  i. Spikes; ii. umbels; iii. racemes, &c.

III. Mixed.
1 Racemes of scorpoid cymes.
2 Scorpoid cyme of capitula.
3 Umbel of bifurcating cymes.
4 Capitula of scorpoid cymes.
&c., &c., &c.

THE GERMAN LANGUAGE.—CHAPTER VIII.

EMPLOYMENT OF AUXILIARIES OF MOOD—CLASSIFICATION AND CONJUGATION OF VERBS, REGULAR, MIXED, IRREGULAR—NEGATIVE, INTERROGATIVE, PASSIVE, REFLEXIVE, AND IMPERSONAL VERBS—EXERCISES.

In the previous lesson we presented, in full, the conjugation of the auxiliary verbs of mood. Like similar auxiliaries in English they are frequently used in an idiomatic manner, and have a tendency to fall into specialities of phraseology, in which they depart from their original etymological meaning. As aids to the comprehension of their uses we subjoin the following hints with illustrative examples.

I. Können signifies (1) to be able, and (2) to be at liberty to do a thing; as Sie können das thun, wenn Sie wollen, you may do that, if you like. Indeed, it is more usual to express the latter idea by können than by mögen. The infinitive after können is sometimes omitted; as Gott kann [thun] alles was er will, God can do all that he wills; Können Sie Deutsch [sprechen]? can you (speak) German?

II. Dürfen signifies (1) to dare; (2) to be permitted or unrestrained; as Darf ich fragen? may I ask? Sie dürfen es wissen, you may know it; and (3) sometimes to need; as Es dürfte alsdann nicht der Fall seyn, it need not then be the case.

III. Mögen signifies (1) being permitted (being at liberty to do a thing); as Er mag lachen, er mag weinen, ich verbiete es nicht, he may laugh, he may cry, I do not forbid it : (2) chance or possibility (especially in the imperfect of the subjunctive mood); as Es möchte regnen, it might rain: (3) wish or desire (particularly in the present and imperfect of the subjunctive); as Möge er lange leben! may he live long! Ich möchte wohl etwas davon haben, I should like to have some part of it: (4) to be able; as Wer mag deine Wunder erzählen! who can recount thy wonders! (though in this sense the compound Vermögen is chiefly used): and (5) to like; with this meaning it is connected with the infinitive; as Ich mag es nicht thun, I do not like to do it; and also may, like a transitive verb, take an accusative case; as Ich mag das nicht, I do not like that. It is frequently applied to what is eaten or drunk; as Mögen Sie Sauerkraut? do you like sour-krout? Nein ich mag es nicht, no, I do not like it. In these cases, however, an infinitive, such as essen, to eat, or trinken, to

drink, may be understood; and the construction thus explained, with the accusative, may be considered as elliptical.

IV. Müssen is almost exactly the English *must*, now and then *ought*, and *to be obliged*; as Ich muß meiner freund vertheidigen, I ought to defend my friend. With a negative it occasionally signifies *need not.*

V. Sollen denotes (1) to be obliged by need or duty, and may be rendered by *shall, must, ought, am to;* as Du sollst das thun, thou shalt do that; Sie sollen schreiben, you are (in duty bound) to write: (2) to be bidden or under command; as Ich soll dahin gehen, I am to go there: (3) to be authorized or permitted; as Soll ich es thun, oder nicht? may I do it or not? and (4) to be said or reported; as Der König soll angekommen seyn, the king is said to have arrived. Sollen is very frequently employed idiomatically in the conditional future; as Wenn er kommen sollte, if he should come; Wenn das so seyn sollte, if that should be so. It is often used with an ellipsis, when the infinitive of some other verb is to be supplied. In this way several phrases are to be explained; as Was soll ich? what shall I? where we require to supply thun, do; Was soll er? what is he to do? or what is he wanted for? Was soll das, what shall that, in which we must supply seyn, be.

VI. Wollen, not being an auxiliary of tenses, is never used to denote future time. It expresses (1) will, intention, inclination; as Ich will lesen, I wish to read: and (2) to maintain, assert; as Er will den Kometen schon gesehen haben, he will have it [*i.e.* asserts] that he has already seen the comet.

VII. Lassen means (1) to let or allow, Lassen Sie ihn gehen, let him go; (2) to get, to make, to cause; as Ein Haus bauen lassen, to get a house built; einen Rock machen lassen, to get a coat made; (3) to leave, Lassen Sie das bleiben, leave that alone. The first person plural of the imperative is seldom used in German. The verb lassen, to let, is, as in English, employed to express that idea. Now and then the imperative is found in use; as Gehen wir, let us go; haben wir Geduld, let us have patience; reden wir nicht mehr davon, let us say no more about it.

These seven verbs of mood—können, dürfen, mögen, müssen, sollen, wollen, and lassen—as well as the verbs heißen, to bid; helfen, to help; hören, to hear; sehen, to see, have this peculiarity, that in compound tenses their infinitive is used instead of their past participle, when it is preceded by another verb in the infinitive; as Warum hast du gehen wollen, why did you wish to go? er hat es zurückgeben müssen, he has been obliged to return it; Man hat mich nicht reden lassen, they did not allow me to speak; ich habe sie kommen sehen, I saw them come.

EXERCISES.

Translate the following German sentences, using a dictionary where necessary, and only referring to the English here given for an explanation when some special difficulty is met with:—

I. Der Vogel kann singen. Man kann im Dunkeln nicht lesen. Niemand kann zwei Herren dienen. Ein guter Baum kann nicht arge Früchte bringen, und ein fauler Baum kann nicht gute Früchte bringen.

The bird can sing. One cannot read in darkness. No man can serve two masters. A good tree cannot bring forth evil fruits, and a corrupt tree cannot bring forth good fruit.

II. Er darf nicht singen. Du darfst den Brief lesen. Die Schildwache darf nicht schlafen.

He dares not sing. Thou mayst [*i.e.* nothing hinders you] read the letter. The sentinel must not sleep.

III. Er mag singen. Du magst den Brief lesen. Er mag jetzt schlafen gehen. Er mag nicht singen. Ich mag den Brief nicht lesen. Er mag keinen Wein trinken. Ich möchte gern schlafen.

He may sing. Thou mayst [*i.e.* you are at liberty] to read the letter. He may now go to sleep. He may not sing. I may not read the letter. He must drink no wine. I would gladly sleep.

IV. Gedenke, daß wir Alle sterben müssen. Wer zu Gott kommen will, der muß glauben, daß er sei. Der Schwächere muß dem Stärkeren weichen. Man muß immer die Wahrheit reden. Wir müssen unsern Feinden verzeihen.

Bethink yourselves, that we must all die. He who would come to God must believe that he is. The weaker must give way to the stronger. One must always speak the truth. We should forgive our foes.

V. Der Knabe soll zeichnen lernen. Ich soll einen Brief schreiben. Du sollst mit mir gehen.

The boy is to learn to draw. I must write a letter. Thou art to go with me.

VI. Der Knabe will spielen. Ich will einen Brief schreiben. Willst Du mit mir gehen?

The boy wishes to play. I want to write a letter. Will you go with me?

VII. Sie lassen den Dieb weglaufen. Lasse ihn schlafen. Er ließ den Hund tanzen. Der Herr läßt den Gerechten nicht Hunger leiden.

They allow the thief to escape. Let him sleep. He made the dog dance. The Lord permits not the righteous to suffer hunger.

VIII. Ich habe nicht schlafen können. Er hat nicht sprechen dürfen. Er hat gehorchen müssen. Er hätte Dich suchen sollen.

I have not been able to sleep. He has not dared to speak. He has had to obey. He ought to have sought thee.

Verbs are divided, according to their meaning, into two principal classes—*transitive* and *intransitive.*

Transitive verbs are active verbs, the sense of which is not complete without the addition of an object in the accusative case; as Ich schreibe einen Brief, I am writing a letter.

Transitive verbs have two forms, called voices, the *active* and the *passive.* If the subject as agent acts upon another person or thing the verb is in the *active* voice; the person or thing acted upon is called the object of the verb, and is put in the accusative case; as Ich rufe ihn, I call him. If the subject of the verb is itself the object of the action expressed by the verb, it is said to be in the *passive* voice; as Ich werde gerufen, I am called. The whole of the passive voice is formed by means of auxiliary verbs, just as in English, *e.g.* Ich werde geliebt, I am loved.

Intransitive verbs denote either a simple state of existence, as Ich ruhe, I am resting; or an activity which does not pass over to any external object, as Ich laufe, I am running. They do not, from the nature of their signification, admit of a passive voice, but have the active form only; as Ich reise, I am travelling. When the active subject either cannot be named, or is designedly left indeterminate, intransitive verbs may be used impersonally in the third person singular of the passive voice; as Es wird getanzt, there is dancing going on.

The class of intransitive verbs may be said also to comprehend *reflexive* verbs. Of these there are two kinds, namely, such as are employed in the reflexive form only, as Sich freuen, to rejoice; and such as are formed from transitive verbs by the addition of the reflexive pronouns mich, uns, dich, euch, sich; as Ich lege mich, I lie down.

Verbs must also be arranged in classes for purposes of conjugation.

Jacob Ludwig Grimm, the distinguished German philologist, first drew a scientific distinction between the two leading conjugations of verbs, which he denominates "strong" and "weak," while K. F. Becker, who revolutionized grammatical teaching in Germany, characterizes them as "ancient" and "modern." The former designation is perhaps the more logically correct, the latter more practically useful. Properly understood they may safely enough be used interchangeably. In some German grammars the old or strong form is treated as "irregular," while the new or weak form is regarded as "regular," as similar verbs are frequently yet classified in English grammars. The fundamental distinction is this:—(1) The *strong* conjugation is inflected mainly within its own roots by such internal change or modification of the radical vowel as shows that a vital power of variation operates within it, and indicates a growing and reproductive capacity of self-development; (2) the *weak* conjugation does not change its radical vowel. Its inflexions are produced by addition from without rather than by effort of vital power within.

We may take as examples the German verbs geben and leben, with their English correlatives *give* and *live.* In each language the former verb belongs to the old strong form.

presenting in its past tense and past participle this power of inward change—thus geben, to give; gab, gave; gegeben, given; while the latter asserts to itself no power of internal modification, but takes only these external changes—leben, to live; lebte, lived; gelebt, lived.

These three principal parts (1) the infinitive, (2) the imperfect or past tense, and (3) the past participle, exhibit the main elements of the verb, and enable us to know the type-form to which it is similar, and therefore indicate how it is to be conjugated.

I. The modern, weak, or *regular* conjugation makes no change in the vowel of its root, *i.e.* the infinitive divested of the conjugational en, but adds to it the termination te (or in certain cases ete) to form the imperfect or past tense, and to form the past participles it prefixes ge and adds t (or et), as loben, to praise; ich lobte, I praised; gelobt, praised. From their simplicity and uniformity verbs belonging to this class are called *regular* verbs, and we shall in future allude to them as such. They will present little difficulty to the student, as he has already mastered their mode of conjugation in learning the verb haben, to have.

II. *Mixed* verbs are those which have the same termination as the regular verbs in the imperfect indicative and in the present participle, but which also change the radical vowel as strong or irregular verbs do; as kennen, to know; ich kannte, I knew; gekannt, known.

III. In ancient, strong, or *irregular* verbs the imperfect or past tense is formed by taking the true (original) root of the verb (often found by throwing off the en of the infinitive), and changing the radical vowel according to the root-type to which the verb belongs, as shall be fully explained below; and the past participle is formed by prefixing ge to the root with or without changing the radical vowel according to the type to which it belongs; as Singen, to sing; ich sang, I sang; gesungen, sung.

In commiting to memory the following paradigms or model forms of the strong and weak conjugations, the acquiring of a mastery over the details of conjugation will present less difficulty to the student if he will carefully notice as he goes along the likenesses between English and German conjugations. For instance, the only parts of the verb which really undergo inflexional change or modification are (1) the infinitive, (2) the present and the imperfect indicative (active), (3) the imperative, and (4) the participles. The rest of the active voice and the whole of the passive voice are, as in English, formed by a combination of the participles or infinitives of the principal verb, with certain (conjugated) tenses of the auxiliary verbs. We therefore only print one or two persons of each of these (compound) tenses, as the student should be able to make up the rest of the tense for himself, if he has properly mastered the verbs in preceding lessons.

In the imperative mood we give the regular forms, but the following modes of expression are very commonly employed: er soll singen, let him sing (*i.e.* he shall, or is to sing); laßt uns singen, let us sing. See VII. p. 532.

CONJUGATION OF VERBS.

I. Regular—Lieben, To Love.		II. Mixed—Kennen, To Know.		III. Irregular—Singen, To Sing.	

Indicative Mood.

PRESENT TENSE.

S. 1. Ich lieb-e,	I love.	Ich kenn-e,	I know.	Ich sing-e,	I sing.
2. du lieb-st,	thou lovest.	du kenn-st,	thou knowest.	du sing-st,	thou singest.
3. er lieb-t,	he loves.	er kenn-t,	he knows.	er sing-t,	he sings.
P. 1. wir lieb-en,	we love.	wir kenn-en,	we know.	wir sing-en,	we sing.
2. ihr lieb-t,	you love.	ihr kenn-t,	you know.	ihr sing-et,	you sing.
3. sie lieb-en,	they love.	sie kenn-en,	they know.	sie sing-en,	they sing.

IMPERFECT TENSE.

S. 1. Ich lieb-te,	I loved.	Ich kann-te,	I knew.	Ich sang,	I sang.
2. du lieb-test,	thou lovedst.	du kann-test,	thou knewest.	du sang-est,	thou sangest.
3. er lieb-te,	he loved.	er kann-te,	he knew.	er sang,	he sang.
P. 1. wir lieb-ten,	we loved.	wir kann-ten,	we knew.	wir sang-en,	we sang.
2. ihr lieb-tet,	you loved.	ihr kann-tet,	you knew.	ihr sang-et,	you sang.
3. sie lieb-ten,	they loved.	sie kann-ten,	they knew.	sie sang-en,	they sang.

PERFECT TENSE.

Ich habe ge-lieb-t,	I have loved.	Ich habe ge-kann-t,	I have known.	Ich habe ge-sung-en,	I have sung.
du hast geliebt,	thou hast loved.	du hast gekannt,	thou hast known.	du hast gesungen,	thou hast sung.
&c.	&c.	&c.	&c.	&c.	&c.

PLUPERFECT TENSE.

Ich hatte geliebt,	I had loved.	Ich hatte gekannt,	I had known.	Ich hatte gesungen,	I had sung.
du hattest geliebt,	thou hadst loved.	du hattest gekannt,	thou hadst known.	du hattest gesungen,	thou hadst sung.
&c.	&c.	&c.	&c.	&c.	&c.

FUTURE TENSE.

Ich werde lieb-en,	I shall love.	Ich werde kenn-en,	I shall know.	Ich werde sing-en,	I shall sing.
du wirst lieben,	thou wilt love.	du wirst kennen,	thou wilt know.	du wirst singen,	thou wilt sing.
&c.	&c.	&c.	&c.	&c.	&c.

FUTURE PERFECT TENSE.

Ich werde geliebt haben,	Ich werde gekannt haben,	Ich werde gesungen haben,
I shall have loved.	I shall have known.	I shall have sung.
&c.	&c.	&c.

Conditional Mood.

PRESENT TENSE.

Ich würde lieben,	I should love.	Ich würde kennen,	I should know.	Ich würde singen,	I should sing.
du würdest lieben,	thou wouldst love.	du würdest kennen,	thou wouldst know.	du würdest singen,	thou wouldst sing.
&c.	&c.	&c.	&c.	&c.	&c.

PERFECT TENSE.

Ich würde geliebt haben,	Ich würde gekannt haben,	Ich würde gesungen haben,
I should have loved.	I should have known.	I should have sung.
&c.	&c.	&c.

Subjunctive Mood.

PRESENT TENSE.

S. 1. Ich lieb-e,	I may love.	Ich kenn-e,	I may know.	Ich sing-e,	I may sing.
2. du lieb-est,	thou mayst love.	du kenn-est,	thou mayst know.	du sing-est,	thou mayst sing.
3. er lieb-e,	he may love.	er kenn-e,	he may know.	er sing-e,	he may sing.
P. 1. wir lieb-en,	we may love.	wir kenn-en,	we may know.	wir sing-en,	we may sing.
2. ihr lieb-et,	you may love.	ihr kenn-et,	you may know.	ihr sing-et,	you may sing.
3. sie lieb-en,	they may love.	sie kenn-en,	they may know.	sie sing-en,	they may sing.

IMPERFECT TENSE.

S. 1. Ich lieb-te,	I might love.	Ich känn-e,	I might know.	Ich säng-e,	I might sing
2. du lieb-test,	thou mightst love.	du känn-est,	thou mightst know.	du säng-est,	thou mightst sing.
3. er lieb-te,	he might love.	er känn-e,	he might know.	er säng-e,	he might sing.
P. 1. wir lieb-ten,	we might love.	wir känn-en,	we might know.	wir säng-en,	we might sing.
2. ihr lieb-tet,	you might love.	ihr känn-et,	you might know.	ihr säng-et,	you might sing.
3. sie lieb-ten,	they might love.	sie känn-en,	they might know.	sie säng-en,	they might sing.

PERFECT TENSE.

Ich habe geliebt,	I may have loved.	Ich habe gekannt,	I may have known.	Ich habe gesungen,	I may have sung.
&c.	&c.	&c.	&c.	&c.	&c.

PLUPERFECT TENSE.

Ich hätte geliebt,	I might have loved.	Ich hätte gekannt,	I might have known.	Ich hätte gesungen,	I might have sung.
&c.	&c.	&c.	&c.	&c.	&c.

FUTURE TENSE.

Ich werde lieben,	I shall love.	Ich werde kennen,	I shall know.	Ich werde singen,	I shall sing.
du werdest lieben,	thou wilt love.	du werdest kennen,	thou wilt know.	du werdest singen,	thou wilt sing.
&c.	&c.	&c.	&c.	&c.	&c.

FUTURE PERFECT TENSE.

Ich werde geliebt haben,	Ich werde gekannt haben,	Ich werde gesungen haben,
I shall have loved.	I shall have known.	I shall have sung.
&c.	&c.	&c.

Imperative Mood.

Liebe (du),	love (thou).	Kenne (du),	know (thou).	Singe (du),	sing (thou).
liebe er,	let him love.	kenne er,	let him know.	singe er,	let him sing.
lieben wir,	let us love.	kennen wir,	let us know.	singen wir,	let us sing.
liebet (ihr),	love (ye).	kennet (ihr),	know (ye).	singet (ihr),	sing (ye).
lieben sie,	let them love.	kennen sie,	let them know.	singen sie,	let them sing.

Infinitive Mood.

Pres. Lieben,	to love.	Kennen,	to know.	Singen,	to sing.
Perf. Geliebt haben,	to have loved.	Gekannt haben,	to have known.	Gesungen haben,	to have sung.
Fut. Lieben werden,	to be about to love.	Kennen werden,	to be about to know.	Singen werden,	to be about to sing.

Participles.

Pres. Liebend,	loving.	Kennend,	knowing.	Singend,	singing.
Past Geliebt,	loved.	Gekannt,	known.	Gesungen,	sung.

The following remarks on the conjugations will assist the memory :—Every German verb terminates in n, or en, in the infinitive; as leben, to live; loben, to praise; tadeln, to blame; trauern, to mourn. The root of the verb is to be found by striking off the termination of the present infinitive [*i.e.* en], the form in which the verb is always given in dictionaries.

In the active voice, only the imperative and the present and imperfect of the indicative and the subjunctive undergo inflexion. The other tenses are compound.

The verb sein serves to form the perfect tenses of most intransitive verbs, as er ist gekommen, he has arrived; haben, to form those of the active and reflective verbs, as er hat es gesagt, he has said it; and werden serves to form the future tenses and the conditional mood of all verbs without distinction.

The first person singular ends in -e (except in a few auxiliaries): Ich kenne, I know.

The second person singular always ends in -st: du liebst, thou lovest; du liebtest, thou lovedst.

The third person singular of the indicative ends in -t, but the subjunctive ends in -e.

The first and third persons plural end in -en, both in the present and imperfect tenses, and it is the same in the subjunctive mood; wir kennen, we know, or we may know; wir sangen, we sang, wir sängen, we might sing.

In many German verbs an e is placed between the root and the termination, to avoid a harsh sound; du redest, thou talkest (instead of redst), er redet, he talks. The student will soon learn to do this unconsciously by ear; but it may be well to remark that this euphonic e is retained through every mood, tense, and person of verbs whose root ends in d, t, gn, chn, or thm. Some verbs have this e only in the second person singular of the present tense; du tanzest, thou dancest.

EXERCISES.

Give the German for—

I. He loves. They love. I loved. We loved. He has loved. Thou hadst loved. They had loved. I shall love. They will have loved. Thou wouldst love. He would have loved. I may love. They may love. He might love. I may-have loved. He might-have loved. Thou wilt love. He will have loved. Love (thou). Let us love. To have loved. Loving. Loved.

II. I know. They know. I knew. We knew. He has known. Thou hadst known. They had known. I shall know. They will have known. Thou wouldst know. He would have known. I may know. They may know. He might know. I may-have known. He might-have known. Thou wilt know. He will have known. Know (thou). Let us know. To have known. Knowing. Known.

III. She sings. They sing. I sang. We sang. She has sung. Thou hadst sung. They had sung. I shall sing. They will have sung. Thou wouldst sing. She would have sung. I may sing. They may sing. She might sing. I may-have sung. She might-have sung. Thou wilt sing. She will have sung. Sing (thou). Let us sing. To have sung. Singing. Sung.

The *passive voice* of all active verbs is formed by their past participle and the auxiliary verb werden, to be or to become, just as the passive voice is formed in English. Remember that the past tenses of werden are formed by the verb sein, to be, and not haben, to have; as, Ich bin geworden, I *have* become; Ich werde geliebt, I am loved; Sie werden geliebt, they are loved; Ich werde geliebt werden, I shall be loved; Ich werde gekannt werden, I shall be known. In compound tenses the past participle of werden comes *last*, and the prefix ge is omitted, so that the participle is written worden, instead of geworden; as, Es ist gesungen worden, it has been sung. There is a form of the passive voice which is compounded with sein instead of werden; but in this case the past participle may be looked on as an *adjective*, and sein as an ordinary auxiliary, yet it is used to express a passive state; as, Das Glas war zerbrochen, the glass was broken; but das Glas wurde von ihm gebrochen, the glass was broken by him, for this sentence describes an action and not a state.

In the *interrogative* form of the verb the pronoun comes after the verb in simple tenses: Kennen Sie? do you know? In compound tenses the pronoun comes immediately after the auxiliary: Haben Sie gekannt? have you known? Werden Sie gekannt haben? shall you have known?

In the *negative* form, nicht, not, comes immediately after the verb in simple tenses, and after the auxiliary in compound ones: Ich kenne nicht, I do not know; Ich habe nicht gesungen, I have not sung.

In the *negative-interrogative* form nicht comes immediately after the pronoun: Kennen Sie nicht? Haben Sie nicht gesungen?

The *reflexive* form is made up with the aid of the reflexive pronouns, which are placed after the verb in simple tenses, and after the auxiliary in compound ones: Ich gräme mich, I grieve myself; Er hat sich gegrämt, he has grieved himself. Some verbs take the reflexive pronoun in the dative case instead of the accusative: Ich schmeichle mir, I flatter myself.

Impersonal verbs are formed out of the third person singular of *any* verb with es, it, for a subject; but of course there are verbs which are only used impersonally; as, Es regnet, it rains; Es hat geregnet, it has rained.

ENGLISH GRAMMAR AND COMPOSITION.
CHAPTER VI.

IRREGULAR VERBS: THEIR NATURE, CONJUGATION, CLASSIFICATION, DERIVATION, AND USE.

THE grammarian's duty is to state clearly, arrange simply, and explain as fully and distinctly as possible the facts of language. Besides the classification of verbs according to their meaning as transitive (*i.e.* not forming in themselves a complete predicate) and intransitive (*i.e.* not requiring the help of other words to complete the predicate), there is a classification according to inflexion which it is necessary to make. We know that the past tense of most verbs is formed by the addition of a terminal syllable to their root, and that in some cases a radical modification takes place in the original word to indicate this change of tense. The former, as being by far the more numerous now, are called regular verbs, and the latter irregular. This term, when invented, was really a name given in the ignorance of the students of language of the processes of change capable of taking place in a living tongue. In language as a living product irregularities are few—although confusion, ambiguity, and anomalies sometimes occur. Necessity and habit regulate the development of speech, and what they require is really regular. The irregular verbs have received this class-name, because it has been found difficult to discover any prevailing general law easily understood and readily expressed explanatory of the changes to which the roots of such verbs were subjected to form their past tense and past participle. The method in which they are formed is not that now common and current. It belongs to a condition of grammatical usage long gone by—a usage which was becoming obsolete even in Saxon times. The words and their forms alike are an historical heritage. They come to us from a time when vigorous originality of life was not so thoroughly stereotyped as it is now. Then experiment was employed to test experience, and a variety of modes were tried to find what was easiest and most expressive—*i.e.* what secured distinctness of articulation, readiness of utterance, and suggestiveness of sound. The old forms were found to be more expressive, while the new forms were the more manageable; and the new habit, charming from its ease, has in the majority of cases superseded the old habit—except in such instances as have, from commonness of use and closeness to the heart, impressed themselves most distinctly on the memory, and incorporated themselves by strong associations to our habitual speech. So fast has been their hold on general usage that despite the tendency in favour of the new forms, the operation of centuries has been unable to supersede them. They must be acknowledged as facts, classify and explain them how we may.

Not only are the (so-called) irregular verbs survivals from the strong original Saxon vocabulary of our ancestors, they are also the most frequently employed; and idiomatically they are the most important, and the most difficult to use with precision and propriety. They are very expressive, mostly monosyllabic, and strong in their self-containedness. The greater number of them possess the same strong independency of formation in almost all the Gothic languages. They are all simple in their intrinsic notion and form. They are all primitive terms descended to us through Saxon, not classical, sources; and while many verbs—such as bow, chew, gnaw, grip, laugh, span, thresh, wash, wield, wreak, &c.—have become weak, no weak verb has ever taken to itself the self-developing habit of the strong formation. No new word, upon its introduction to the language, takes the old form of conjugation, and all such verbs as are derived from these—*e.g. drench* from drink, *awaken* from awake—are all conjugated according to the weak form. These facts concerning strong and weak verbs show that the distinction into strong and weak refers to a natural difference between their methods of formation, and not to mere oddities and incongruities.

The inflected forms of Old English verbs were much more numerous than those which are at present used. All the variations of form which are now in living use are (1) *est* and its contraction *st*, in the second person singular present and past indicative—which, from our disuse of them, are falling greatly out of use; (2) *s* in the third person singular present; and (3) *th* or *eth*, its softened form—very rarely employed; (4) *ing* for the present participle; (5) *d* or *ed* for the past participle, or in the case of strong verbs *en*, which holds the same place and fulfils the same office. On the whole, then, the student has only to attend to the place and use of these (at most) *six* variations, that he may obtain the mastery over the entire inflexional variations of an English verb. The following is a complete paradigm of the irregular (*i.e.* strong) verb *to teach*, given both in the *active* and *passive* voice.

Though, in reality, all the forms of conjugation might be explained in a brief space, and include only those portions of the verb in which inflexional variations occur, it is of great advantage to know the different forms of predication possible, and to have them presented in a classification such as enables the scholar to use it as a help in the study of other languages.

ACTIVE VOICE. To Teach.	PASSIVE VOICE. To be Taught.

INDICATIVE MOOD.

PRESENT TENSE.

Singular.	*Singular.*
1. I teach.	1. I am taught.
2. Thou teachest.	2. Thou art taught.
3. He teaches or teacheth.	3. He is taught.
Plural.	*Plural.*
1. We teach.	1. We are taught.
2. You teach.	2. You are taught.
3. They teach.	3. They are taught.

PRESENT PROGRESSIVE TENSE.

Singular.	*Singular*
1. I am teaching.	1. I am being taught.
2. Thou art teaching.	2. Thou art being taught.
3. He is teaching.	3. He is being taught.
Plural.	*Plural.*
1. We are teaching.	1. We are being taught.
2. You are teaching.	2. You are being taught.
3. They are teaching.	3. They are being taught

IMPERFECT TENSE.

Singular.	*Singular.*
1. I taught.	1. I was taught.
2. Thou taughtst.	2. Thou wast taught.
3. He taught.	3. He was taught.
Plural.	*Plural.*
1. We taught.	1. We were taught.
2. You taught.	2. You were taught.
3. They taught.	3. They were taught.

IMPERFECT PROGRESSIVE TENSE.

Singular.	*Singular.*
1. I was teaching.	1. I was being taught.
2. Thou wast teaching.	2. Thou wast being taught.
3. He was teaching.	3. He was being taught.
Plural.	*Plural.*
1. We were teaching.	1. We were being taught.
2. You were teaching.	2. You were being taught.
3. They were teaching.	3. They were being taught.

PERFECT TENSE.

Singular.	*Singular.*
1. I have taught.	1. I have been taught.
2. Thou hast taught.	2. Thou hast been taught.
3. He has taught.	3. He has been taught.
Plural.	*Plural.*
1. We have taught.	1. We have been taught.
2. You have taught.	2. You have been taught.
3. They have taught.	3. They have been taught.

PERFECT PROGRESSIVE.

Singular.	
1. I have been teaching.	
2. Thou hast been teaching.	
3. He has been teaching.	There is no progressive form in use in the passive voice.
Plural.	
1. We have been teaching.	
2. You have been teaching.	
3. They have been teaching.	

PLUPERFECT TENSE.

Singular.	*Singular.*
1. I had taught.	1. I had been taught.
2. Thou hadst taught.	2. Thou hadst been taught.
3. He had taught.	3. He had been taught.
Plural.	*Plural.*
1. We had taught.	1. We had been taught.
2. You had taught.	2. You had been taught.
3. They had taught.	3. They had been taught.

FIRST FUTURE TENSE.

Singular.	*Singular.*
1. I shall *or* will teach.	1. I shall *or* will be taught.
2. Thou shalt *or* wilt teach.	2. Thou shalt *or* wilt be taught.
3. He shall *or* will teach.	3. He shall *or* will be taught.
Plural.	*Plural.*
1. We shall *or* will teach.	1. We shall *or* will be taught.
2. You shall *or* will teach.	2. You shall *or* will be taught.
3. They shall *or* will teach.	3. They shall *or* will be taught.

SECOND FUTURE TENSE.

Singular.	*Singular.*
1. I shall *or* will have taught.	1. I shall *or* will have been taught.
2. Thou shalt *or* wilt have taught.	2. Thou shalt *or* wilt have been taught.
3. He shall *or* will have taught.	3. He shall *or* will have been taught.
Plural.	*Plural.*
1. We shall *or* will have taught.	1. We shall *or* will have been taught.
2. You shall *or* will have taught.	2. You shall *or* will have been taught.
3. They shall *or* will have taught.	3. They shall *or* will have been taught.

IMPERATIVE MOOD.

Singular.	*Singular.*
	1. Let me be taught.
2. Teach thou *or* do thou teach.	2. Be thou *or* do thou be taught.
	3. Let him be taught.
Plural.	*Plural.*
	1. Let us be taught.
2. Teach you *or* do you teach.	2. Be you *or* do you be taught.
	3. Let them be taught.

POTENTIAL MOOD.

PRESENT TENSE.

Singular.	*Singular.*
1. I may *or* can teach.	1. I may *or* can be taught.
2. Thou mayst *or* canst teach.	2. Thou mayst *or* canst be taught.
3. He may *or* can teach.	3. He may *or* can be taught.
Plural.	*Plural.*
1. We may *or* can teach.	1. We may *or* can be taught.
2. You may *or* can teach.	2. You may *or* can be taught.
3. They may *or* can teach.	3. They may *or* can be taught.

IMPERFECT TENSE.

Singular.	*Singular.*
1. I might, could, would, *or* should teach.	1. I might, could, would, *or* should be taught.
2. Thou mightst, couldst, wouldst *or* shouldst teach.	2. Thou mightst, couldst, wouldst *or* shouldst be taught.
3. He might, could, would, *or* should teach.	3. He might, could, would, *or* should be taught.
Plural.	*Plural.*
1. We might, could, would, *or* should teach.	1. We might, could, would, *or* should be taught.
2. You might, could, would, *or* should teach.	2. You might, could, would, *or* should be taught.
3. They might, could, would, *or* should teach.	3. They might, could, would, *or* should be taught.

PERFECT TENSE.

Singular.	*Singular.*
1. I may *or* can have taught.	1. I may *or* can have been taught.
2. Thou mayst *or* canst have taught.	2. Thou mayst *or* canst have been taught.
3. He may *or* can have taught.	3. He may *or* can have been taught.
Plural.	*Plural.*
1. We may *or* can have taught.	1. We may *or* can have been taught.
2. You may *or* can have taught.	2. You may *or* can have been taught.
3. They may *or* can have taught.	3. They may *or* can have been taught.

PLUPERFECT TENSE.

Singular.	*Singular.*
1. I might, could, would, *or* should have taught.	1. I might, could, would, *or* should have been taught.
2. Thou mightst, couldst, wouldst *or* shouldst have taught.	2. Thou mightst, couldst, wouldst *or* shouldst have been taught.
3. He might, could, would, *or* should have taught.	3. He might, could, would, *or* should have been taught.
Plural.	*Plural.*
1. We might, could, would, *or* should have taught.	1. We might, could, would, *or* should have been taught.
2. You might, could, would, *or* should have taught.	2. You might, could, would, *or* should have been taught.
3. They might, could, would, *or* should have taught.	3. They might, could, would, *or* should have been taught.

SUBJUNCTIVE MOOD.

PRESENT TENSE.

Singular.	*Singular.*
1. If I teach.	1. If I be taught.
2. If thou teach.	2. If thou be taught.
3. If he teach.	3. If he be taught.
Plural.	*Plural.*
1. If we teach.	1. If we be taught.
2. If you teach.	2. If you be taught.
3. If they teach.	3. If they be taught.

IMPERFECT TENSE.

Singular.	*Singular.*
1. If I taught.	1. If I were taught.
2. If thou taught.	2. If thou wert taught.
3. If he taught.	3. If he were taught.
Plural.	*Plural.*
1. If we taught.	1. If we were taught.
2. If you taught.	2. If you were taught.
3. If they taught.	3. If they were taught.

PERFECT TENSE.

Singular.	*Singular.*
1. If I have taught.	1. If I have been taught.
2. If thou have taught.	2. If thou have been taught.
3. If he have taught.	3. If he have been taught.
Plural.	*Plural.*
1. If we have taught.	1. If we have been taught.
2. If you have taught.	2. If you have been taught.
3. If they have taught.	3. If they have been taught.

PLUPERFECT TENSE.

Singular.	*Singular.*
1. If I had taught.	1. If I had been taught.
2. If thou hadst taught.	2. If thou hadst been taught.
3. If he had taught.	3. If he had been taught.
Plural.	*Plural.*
1. If we had taught.	1. If we had been taught.
2. If you had taught.	2. If you had been taught.
3. If they had taught.	3. If they had been taught.

FIRST FUTURE TENSE.

Singular.	*Singular.*
1. If I shall *or* will teach.	1. If I shall *or* will be taught.
2. If thou shalt *or* wilt teach.	2. If thou shalt *or* wilt be taught.
3. If he shall *or* will teach.	3. If he shall *or* will be taught.
Plural.	*Plural.*
1. If we shall *or* will teach.	1. If we shall *or* will be taught.
2. If you shall *or* will teach.	2. If you shall *or* will be taught
3. If they shall *or* will teach.	3. If they shall *or* will be taught.

SECOND FUTURE TENSE.

Singular.	*Singular.*
1. If I shall *or* will have taught.	1. If I shall *or* will have been taught.
2. If thou shalt *or* wilt have taught.	2. If thou shalt *or* wilt have been taught.
3. If he shall *or* will have taught.	3. If he shall *or* will have been taught.
Plural.	*Plural.*
1. If we shall *or* will have taught.	1. If we shall *or* will have been taught.
2. If you shall *or* will have taught.	2. If you shall *or* will have been taught.
3. If they shall *or* will have taught.	3. If they shall *or* will have been taught.

INFINITIVE MOOD.

PRESENT.	PRESENT.
To teach *or* to be teaching.	To be taught.
PERFECT.	PERFECT.
To have taught *or* to have been teaching.	To have been taught.

PARTICIPLES.

Present—Teaching.	Being taught.
Perfect—Taught.	Taught.
Compound Perf.—Having taught.	Having been taught.

The verb, we know, is the most highly organized element of human speech. It is the means by which the mind expresses its judgments on all matters of thought. From the importance of its agency in the service of the most central and dominant of the activities of thought it derives its name, and from the importance of its office it has attracted to itself a large number of accessory elements. Generative philology has not yet succeeded in showing by what process of internal development and self-modification, and by what modes of natural selection, the verb has aggregated to itself so many forms of change—nor does it inform us of the presiding reason for the self-developing power of the strong verbs in olden times, and the adoption of the more modern uniformity and simplicity of external inflexion in the weak verbs. One obvious advantage of the latter system is its almost mechanical readiness of management.

Sound is used to express thought. Interchanges of sound, subtle but certain, suggest changes of signification, *e.g.* drip, drop; drift, draft; bench, bunch, &c. A quick and vivid sympathy seizes upon the chime of sound as indicative of a notion of the thing, and seeks to express pleasant things by pleasing sounds and unpleasant ones by harsh ones, *e.g.* smooth, whizz, &c. This mastery of sound over both sense of hearing and sensitiveness of thought probably contains the secret of the endeavour to exhibit the changes occurring in given acts expressed by verbs by the modification of sound made within the words employed. We might thence construct for ourselves an ideal of the manner in which men endeavoured to manage the internal modifications of verbs. The characteristic feature of these verbs being accepted as that of indicating by an internal vowel-change the modifications of idea intended to be understood, we may suppose the process to have been somewhat like this:—

Taking a well-defined consonantal framework as possessing a distinct power of suggestion, our Saxon forefathers found that by introducing into them a different vowel-sound they could indicate certain differences, and so provide themselves promptly with a change of form suggestive of a change of signification. In this way the range of expression was largely increased, and the power of the limited vocabulary of these primitive people was greatly improved. The vowels *i*, *a*, *u* are cardinal or primary, and those of *o* and *e* subordinate or secondary. Their vibratory power indicates this—*i* gives 7200 vibrations per second, *a* 1800 or one-fourth, and *u* 450, which is again one-fourth of the vibratory intensity of *a*; *e* as an intermediate between *i* and *a* gives the half of *i* and double of *a*, viz. 3600, and *o* as the intermediate between *a* and *u* gives the half of *a* and double of *u*, viz. 900. This chromatic distinction of vowel-sounds became the formal and methodical, that is, in fact, the regular characteristic of the old verb—viz. change of vowel in some regular series.

The *first* class of strong verbs may be regarded as those which form their past tense and past participle by internal vowel changes. Of these the first subclass take the primary vocalic series *i*, *a* (or *u*), *u*. Of course, to us now the formative peculiarities of these strong verbs have become rather troublesome to understand and deal with, and some help towards making them less so by classification and explanation may be found convenient. We suggest the following arrangement:—

Begin	began	begun.	Sling	slang / slung	slung.
Cling	clung	clung.	Slink	slank / slunk	slunk.
Dig	dug / digged	dug. digged.	Spin	span	spun.
Drink	drank	drunk.	Spring	sprang	sprung.
Fling	flung	flung	Stink	stank	stunk.
Hang	hung	hung.	String	strang / strung	strung.
Hang	hanged	hanged.	Swim	swam / swum	swum.
Ring	rang / rung	rung.	Swing	swang / swung	swung.
Run	ran	run.	Win	won	won. Pronounced wun.
Shrink	shrank / shrunk	shrunk.	Wring	wrung	wrung.
Sing	sang / sung	sung.			
Sink	sank / sunk	sunk.			

The *second* subclass may be taken as having the vocal series *i* and *ou* (diphthong):—

Bind	bound	bound.	Grind	ground	ground.
Fight	fought	fought.	Think	thought	thought.
Find	found	found.	Wind	wound	wound.

The *third* sub-class has *i*, *a*, *a*:—

Sit	sat (sate)	sat (sitten).	Spit	spat	spat (spitten).

The *fourth* subclass is characterized by *i*, *o*, *o*:—

Abide	abode	abode.	Shine	shone	shone.

In the *second* class of strong verbs no change is made in the past tense or past participle, but all these parts are alike. These are—beat [beaten], burst, cast, cost, cut, hit, hurt, knit [knitted], let, put, rid, set, shed, shred, shut, slit, split, spread, sweat [sweated], and thrust.

The *third* class of strong verbs are characterized by an internal vowel-change in the past, and the addition of the suffix *n* or *en*, to form the past participle [with such euphonic changes as this involves]. These may be arranged into subclasses as follows:—

(1) *i*, *o*, *i*.

Abide	abode	abidden. abode.
Arise	arose	arisen.
Drive	drove	driven.
Ride	rode	ridden.
Rise	rose	risen.
Shrive	shrove	shriven.
Smite	smote	smitten.
Strive	strove	striven.
Thrive	throve	thriven.
Write	wrote	written.

(2) *o*, *e*, *ow*.

Blow	blew	blown.
Crow	crew	crown. crowed.
Grow	grew	grown.
Know	knew	known.
Shew	shewed	shewn.
Throw	threw	thrown.

(3) *o*, *e*, *e*.

Behold	beheld	beheld [beholden]
Hold	held	held [holden]

(4) *a*, *e*, *a*.

Befall	befell	befallen.
Draw	drew	drawn.
Fall	fell	fallen.

(5) *e*, *ee*, *ea*, *o*, *o*.

Bear	bore bare	born. borne.
Forbear	forbore	forborne.
Break	brake broke	broken.
Choose	chose	chosen.
Cleave	clove cleft	cloven. cleft.
Freeze	froze	frozen.
Get	got gat	gotten.
Beget	begot begat	begotten.
Lose	lost	lost.
Sell	sold	sold.
Shear	shore sheared	shorn.
Speak	spoke spake	spoken.
Steal	stole	stolen.
Swear	swore sware	sworn.
Tear	tore	torn.
Tell	told	told.
Tread	trod	trodden.
Wear	wore	worn.
Weave	wove	woven.

(6) *a*, *o*, *a*.

Forsake	forsook	forsaken.
Shake	shook	shaken.
Stave	stove	staven.
Take	took	taken.
Wake	woke	waken.
Awake	awoke	awaken.

(7) *i*, *a* or *i*, *i*.

Bid	bade bid	bid. bidden.
Forbid	forbade forbid	forbid. forbidden.
Bite	bit	bitten. bit.
Chide	chid	chidden. chid.
Give	gave	given.
Hide	hid	hidden. hid.
Lie	lay	lain. lien.
Rive	rived	riven. rived.
Slide	slid	slidden.
Stride	strode strid	stridden.
Strike	struck	struck. stricken.

GEOLOGY.—CHAPTER VI.

IGNEOUS ROCKS—GRANITE, GNEISS, AND OTHER PRIMARY CRYSTALLINE FORMATIONS.

THE biography of the globe is not likely soon to be written in full. It is old and we are young. The investigations necessary to discover its birth-date and original state depend on far-scattered, much-altered, and not very easily decipherable monuments and records. These are not easily reached at first hand, and few can read them with undisputed accuracy even when the rock-written evidence is before the eye. A sort of general idea is all that can readily be formed by the best specialists, and they concur in holding something like the following opinion. The earth is an oblate spheroid, the materials of which at the epoch of its formation must have been in a fluid state. The original particles of which the earth is composed are regarded as having been (and in large part as being even now) in a state of igneous fusion. This mighty mass of liquid fire, after having assumed the spheroidal form, gradually cooled down, hardened, and solidified, and after undergoing many changes, assumed its present condition. In the process of cooling, a superficial spherical shell or outer crust of considerable solidity incased these igneous masses, and was itself everywhere encircled with a watery vapour, which, condensing on that surface, formed upon it the materials subsequently gathered together into seas and oceans, and collected into an all-surrounding atmosphere. The solidified substance which incloses the densely compressed material of the globe, as these heat-fused rocks cooled down, became too large a packing case for the subjacent matter. As a consequence, cracks in, and sinkings of, the telluric crust afforded openings for the outrush of the internal molten matter through rifts and crevices, and occasioned hollows and depressions into which the surface waters could settle and find place. Thus the mobile fluid of the surfaces filled up the ocean basins, and the fiery tides of the inner igneous masses were not only injected into portions of the riven casing, but projected through the terrestrial shell, so as to form when cooled ridges and peaks. To the investigation of the phenomena of that outer solid rind which lies between the aerial envelope and the underlying and possibly liquid material of the globe, geology devotes its researches.

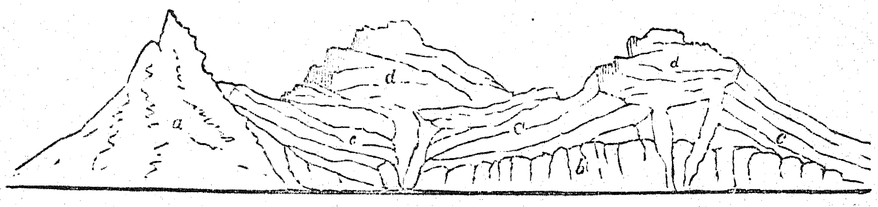
The hardest and firmest of the rocks which human research has reached contain marks of having been, at some time or other, in a liquid state—molten by heat. They are all crystallized; and the fundamental layer—that which is, so far as known to us, nearest to the igneous liquid material mass of the earth, and forms the lowest portion of the external solid shell—consists entirely of contesserated agglomerations of mineral matter in a state of crystallization. When matter has been fused by intense heat, and been subsequently cooled until it has gradually solidified, it very frequently assumes those regular forms which characterize crystals. If a mass of matter, containing different chemical constituents, were brought into a state of fusion, these elements would aggregate themselves according to their mutual affinities, and so assume those various forms proper to their original molecular structure which we call crystals—which may be seen in loaf sugar, in silica or quartz, and in a hundred different varieties of calcareous spar. Such portions of the external crust of the earth as have been brought under the observation of geologists, and are regarded as constituting the primitive rocks, are characterized by these crystalline forms; and hence it has been inferred that they were in their original condition in a state of igneous fusion, and that as the incandescent telluric surface gave off its heat by radiation, they were superficially cooled and consolidated. In this way they became the original terrestrial shell, which however, crushed and folded, rent and riven, retains in the main its stability, and remains even yet the most solid and enduring of the ordinary materials of the solid surface of the globe.

Igneous rocks show no signs of laminar sorting or the stratifying operation of water; they differ in their mode of occurrence and structure, as well as in their composition from the stratified and derivative rocks; they bear a smaller proportion to the whole (observed) masses of rock forming the upper crust of the earth, but they exhibit a much greater variety than sedimentary rocks do; and below every sort of sedimentary and stratified rocks known, those rocks which are unstratified and are regarded as igneous are always found forming a substratum and base. Either simultaneously or successively in all or nearly all parts of the globe the igneous rocks seem to have been in a state of fusion, and many of them appear to have been formed under the influence of strangely intense temperatures, and under the power of immense pressure, where air and water had alike been eliminated from the operating agencies by which bodies are usually affected.

As they appear, at present, the igneous rocks have no very determinate position in the series of layers which form the outer film of the earth's matter. They break through, dislocate, and penetrate the strata—which may be regarded as originally the arranged and orderly state of the earth—and by their plications, contortions, bosses, dykes, and veins, produce a somewhat deranged and disorderly appearance upon the earth's superficial crust. Yet below all the orderly sedimentary rocks which they have disturbed, these unstratified

ones are found, and from the effects which they have produced on the strata among which they have taken a place, their igneous heat may be inferred. Upon the superficial covering of the plastic central fluids of the globe, in which all the manifold ingredients of metals, minerals, earths, and rocks are mingled, blended, and contained, they appear as the representatives of that intense, all-fusing heat which, in its fervency, has crystallized into inorganic masses the original materials of the world. Heat, we know, can liquefy the most obstinate materials, if but sufficiently intense. Not only does it transform ice into water and melt lead, but it can fuse iron, silver, and gold, till they become as fluent as rolling water.

Under the designation of the original flooring of the great round world, these primitive rocks have become familiar to all observant eyes as *granite*—the least perishable of building stones, and therefore most prized for the purpose of permanent constructions. It is believed by modern geologists to be of igneous origin, to descend to an undefined depth, to rest upon the internal liquefied material mass of the globe, and to have been protruded from below through chinks, cracks, crevices, rifts, and openings, in such a way as to elevate the land masses of the surface, to dislocate their strata, and to intertexture itself between them in the form of veins. Granite (Italian *granito*, grained) receives its name from its granular structure. Its grains, however, are not combined chemically or molecularly, but, having been concreted by mere agglomeration and mechanical juxtaposition, they seem to have been brought into cohesion under pressure and compacted by induration. Some geologists of eminence regard even granite as an igneous rock originally derived from some earlier stratified form, but all agree that, so far as investigation—spread as it has been over immense geographical areas—has yet gone, no other rock has been found capable of establishing a claim superior to it of being the first known term in the series which overspread the heat-fused mass of the earth, and formed the lowest known layer of the telluric spheroidal shell —of being, in fact, the incasing skeleton and framework of the globe. Upon it, as on a foundation, the superficial structures of the earth may be said to be reared and made fit for becoming the theatre of life. The following diagram illustrates the mode in which igneous rocks often appear:—



a may represent a granitic mountain axis protruding through the strata which flank it. These strata are shown on the right, and their positions indicate that they have been disruptured and displaced by it. The secondary strata *c* have been deposited since its elevation. *b* may represent columnar basalt, and *d* overlying masses of that rock which have been ejected from beneath through the stratified formations *c c c*.

Granite has claimed no small share of the attention of our most eminent geologists. As it always occurs in the crystalline form, we have the most distinct proof that it originally existed in a fluid state. The proof of this is rendered still more decisive when we examine the manner in which it is often found injected, in the form of veins, into superincumbent strata. Granite was long considered as representing the primordial condition of terrestrial matter, that which—having formed the original external coating of the globe, and been acted on for ages by atmospheric or aqueous agencies—gave origin to the stratified masses which are now generally found resting upon it; but modern discoveries have led to the opinion that even in granite itself we find no trace of the original condition of the primeval rocky masses, and to the hypothesis that granite is that particular state of combination into which any of the stratified deposits may be converted by the combined agencies of heat and pressure.

Granite is a rock of great beauty, and is capable of taking a fine polish. Its crystals, in the typical forms, are mica, felspar, and quartz. Other minerals, such as actinolite, chlorite, talc, compact felspar, steatite, and garnet, enter into and modify its appearance. In colour it varies according to the different hues of the prevailing minerals.

The colours of all its component elements likewise vary. The felspar may be red, grayish-white, white, pale flesh-coloured, yellow or green, and it is chiefly distinguished from quartz by being laminar in its structure. Quartz is usually clear white or gray, but sometimes black. Mica is black, white, gray, brown, and of a silvery appearance, splitting readily into thin transparent plates. Hornblende is black. The felspar and mica in granite are always crystallized; the quartz fills the interstitial spaces left by these minerals; and, in the cavities of such rocks, beautifully crystallized prisms of quartz are not uncommon. The sizes of the grains or crystals are various.

From those varieties of admixture, it is inferred that some of the granitic rocks are nearly, if not wholly, allied to some of the members of the trap family—particularly greenstone, which is composed of hornblende and felspar; and that however diversely modified, the granite and the trap rocks have a common origin.

Granitic mountains are in general wild, rugged, and precipitous, and almost always skirted with other mountains of gneiss or mica slate, the strata of which are highly inclined. The highest mountains are not always composed of this material. Indeed, granite, composed of the usual crystals of mica, felspar, and quartz, is not quite so common as was once supposed. In the Alps and other places it is often seen passing into porphyry, and there can be no doubt that that rock and granite are nearly related in date and material.

The Urals and the Himalayas in Asia, the hill ranges of Abyssinia in Africa, and the Andes in South America, may be regarded as more or less of granitic structure, though they are formed of layers of laminated rock frequently much contorted. In the Scandinavian peninsula the ranges of the Dovrefelds, in Switzerland the Alps, and in Spain the Pyrenees are granitic in the main.

Granite is found in contact with, and altering rocks belonging to the cretaceous period in the Eastern Pyrenees. Sir Charles Lyell mentions the metamorphic character of a limestone containing fossils belonging to the Oolite or Lias formation, which occurs within a few yards of granite in the Hautes Alpes, near Vizille, in France. In another instance, occurring near Champoleon, a granite is observed to overlie secondary rocks, and produce an alteration which extends about 30 feet downward, diminishing in the beds which lie furthest from the granite.

Granite is found traversing Silurian beds and gneiss, near Christiania in Norway. Geologists therefore conclude that granite has been formed at successive periods and under very different conditions. Indeed, on investigating the districts in which granite comes into contact with, or penetrates adjacent strata, some geologists have thought that it was formed under the pressure of the rocks which it penetrates, and altered while these were superimposed upon it in a horizontal or slightly inclined position. We have a beautiful illustration of this in the picturesque Isle of Arran in the Frith of Clyde—an island almost unique as a geölogical gymnasium.

That island is composed, in its northern division, of rocks chiefly consisting of granite, mica slate, and clay slate, with a slight development of the Carboniferous formation; and in its southern division, of sandstone, alternating with beds of limestone, the whole pierced through and overlaid by such igneous rocks as greenstone and basalt, porphyry and pitch-

stone, &c.; on the east coast these same strata form a narrow belt in the north of the island on which true coal-beds accompany the limestone and sandstone. The central mass of the northern portion of the island consists of the granitic mountains of Goatfell and Ceim-na-caillach; the former rising to about 2865 feet above the level of the sea. The granite is flanked by precipitous ridges of schistose rocks, which it penetrates in the form of veins. On the edges of the schists, deposits of red sandstone and conglomerate are followed by limestone containing organic remains common to the oldest carboniferous formations of the mainland. Innumerable veins of trap, and some of pitchstone, penetrate all the rocks from the granite upward. Throughout a great portion of the island, the secondary strata is overlaid by trap rocks. The

Uralskaya Sopka, part of the Ural Mountains.

diagram given below will furnish an idea of the geological conformation of the island.

The granitic mass has evidently, after it had become consolidated, broken through the upheaved schists; and if, from the fact that the same sandstones and limestones occur on either flank of the granite, we may infer that they once formed a continuous deposit over the area of the island, the disruption must have taken place after the deposition of the whole mass. Though its conglomerates consist of quartz and

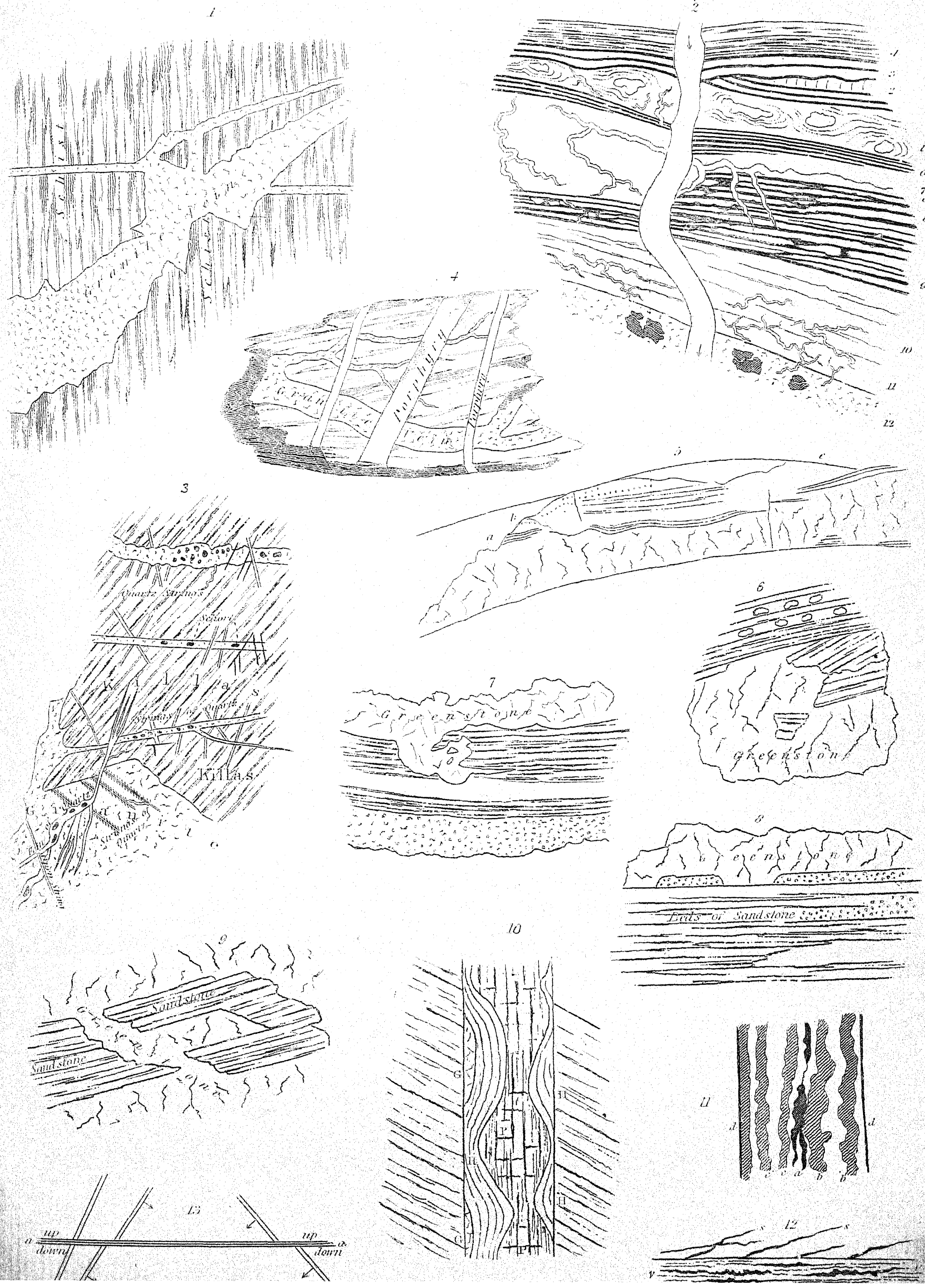
Section of the Island of Arran.

A, Granite. B, Schists. C, Sandstones, conglomerates, &c. D, Trap veins. E, Overlying trap.

other fragments of schists and trap peculiar to the island, we find no trace of granite. It is impossible that they should not also have contained fragments of granite, had it at that time been exposed to the same agencies which denuded and degraded the schists. The conglomerates now aggregating on the coast contain fragments of granite; and immense masses of it, some at very considerable elevations above the level of the sea, are distributed over the island. That proves that the granite was formed prior to the denudation and upheaval of the rocks which flank it.

The chief granite districts in England are those of the counties of Cumberland, Cornwall, and Devon, occurring in several extensive detached masses from the Land's End to Dunsford, near Exeter, and often exhibiting the phenomena of *tors*. These apparently fantastic piles and insulated peaks of granite frequently take singular forms and shapes, which almost simulate architectural ruins. Of these, the *Cheesering*, near Liskeard, is an example. It is a pile about 15 feet high, consisting of five granitic blocks, much decomposed by the weather, the upper ones of which are much larger than the lower. The lofty granitic table-lands of Dartmoor are quarried and the stone conveyed to many large cities. Dartmoor granite is now regarded as of a later date than the culm-beds of that district, which contain the true coal plants, and are therefore regarded as belonging to the carboniferous era. The Cornish granite (which by the miners is called *grouan*) is metalliferous, and on the wedge-shaped promontory from which the western terminal rocks of England, near Land's End, rise to front the dashing assaults of the sea waves, in bluffs of 60 feet high, many peculiarities of granite are to be observed.

The greatest granitic masses of Scotland occur chiefly in the county of Aberdeen. It is almost wholly composed of granite and gneiss. A large tract of granite occurs also between Huntly and Banff, in Banffshire; and tracts of considerable extent intersect portions of the counties of Perth, Inverness, and Sutherland. Ben Cruachan and the peaks which give charm to the south of Loch Etive, and a tract of country on the north of the same loch, are composed of granite. If lines are drawn from the head of Loch Awe to Aberdeen, and to the Moray Frith, the greater part of the space included in that area is filled with gneiss, resting irregularly on the granites of Ben Cruachan, the district of Loch Rannoch, Dalwhinnie, Cairngorm, Aberdeen, and Peterhead. There


1
Schist
Granitic Vein
2
4
Porphyry
3
Quartz Strings
Schorl
Killas
Strings of Quartz
Killas
5
6
Greenstone
7
Greenstone
8
Greenstone
Ends of Sandstone
9
Sandstone
Sandstone
10
11
12
13
up
down
up
down

are two considerable granite districts in the south of Scotland; one on the shores of the Solway Frith to the south-west of Dumfries, and the other in Kirkcudbright, stretching from the south of Loch Doon to a few miles of the shore at Wigtown Bay. The western extremities of the isle of Mull also consist of granite.

In Ireland granitic rocks appear in Wicklow, extending over an area of 66 miles in length by about 20 in breadth, from Kingstown to Wexford, and cropping up at detached points in Carlow and Kilkenny. Over a large district in Down, Louth, and Armagh, granite, flanked by metamorphic bands, rises through the prevailing Silurian slates. In Donegal, where it throws up peaks attaining 2500 feet, granite occupies an area of 35 miles by 18, and along the northern shores of Galway the Atlantic beats against bulwarks of granite. On the north-east of Antrim, opposite Kintyre, a tract of mica slate extends, in which granite appears.

Gneiss is, according to Ansted, a name used by the miners of Saxony, which has, since the days of Werner (1750–1817), been applied to a "crystalline compound of quartz, felspar, and mica, distinctly stratified and widely distributed," "especially abundant in Scotland and the Scandinavian range; and in Bohemia, Silesia, and the metalliferous mountains of Saxony." It is, typically, composed of the same elements as granite, but differs in the mode of their aggregation. In granite they are confusedly and irregularly crystallized; in gneiss they are laminated—*i.e.* arranged in layers. In many instances, however, metamorphism—*i.e.* change in the original structure—has operated so far as to obliterate, in a great measure, the laminar, and to alter it into an almost crystalline formation, as if it were "bedded granite." So much is this the case that it frequently requires the well-trained eye of a skilled geologist to distinguish between some specimens of granite and of gneiss. A wide range is therefore given to the designation gneiss, and many varieties which deviate considerably from the normal structure are recognized and named by having a differentiating adjective attached to it—*e.g.* protogenic, oligoclase, syenitic, or hornblendic gneiss. Some difference of opinion also obtains as to all gneiss being a formation of the older and fundamental series of rocks, or in some instances possibly a product of local metamorphism—whether it is always a form of detrital granite formed anew in a heated ocean, or may sometimes have been an originally foliated structure exposed to crystallizing influences. Its wide diffusion brings it into relation with many other forms of rock structure. Gneiss consists of the same felspathicose quartz and micaceous ingredients as granite, and is often only to be distinguished from it by its laminated structure. Mica slate is less granitic in its appearance, the mica being the predominating mineral and the felspar wanting.

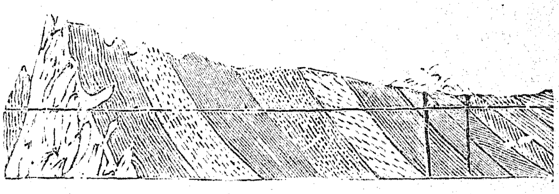
Gneiss, which contains at least three of the four minerals, quartz, mica, felspar, and hornblende, is denominated *regular*, and is called *irregular* when it contains compact felspar, or when of a different composition in other respects. Gneiss and mica slate are among the oldest rocks with which geologists have yet become acquainted. Some writers contend that they ought to be reckoned as of igneous origin equally with granite.

Primary limestone or marble and serpentine are sometimes associated with these formations, and quartz rock is very abundant. Compared with the other formations which compose the solid framework of the globe, they are more indurated, crystalline, and silicious in their composition. The secondary rocks have a greater variety of arenaceous and calcareous beds; while in the Tertiary loose sands marls and clays prevail.

The laminæ of gneiss and mica slate frequently present examples of curvature of the most extraordinary kind. This is not confined to small portions of the rocks, but instances are not uncommon of the whole mass being twisted and bent in a manner that never could have taken place had the rocks always existed in the same indurated manner as at present.

In granite, all the elements are crystallized: each mineral is independently a crystal, or moulded in the cavities left between crystals. In gneiss, mica, and mica schist, the felspar, quartz, and mica are rolled or fragmental masses. The worn surfaces of their ingredients, combined with the lamination or stratification of the mass, assure us that aqueous agencies have determined their aggregation. The lamination of gneiss and mica schist, but especially the minute flexures which abound in these ancient rocks, suggest some peculiarity in the condition of the water in which they were formed; while the internal crystallization of the attrited felspar reveals that they derive their origin from the disintegration of granite.

These deposits are of more general occurrence throughout the crust of the earth than any others. The diagram here given will indicate their general relations among themselves and towards other geological formations.



1. Granite. 2. Gneiss. 3. Mica schist. 4. Clay slate. 5. Silurian rocks. 6. Old red sandstone. 7. Mountain limestone. 8. Lower coal formation 9. Upper coal formation.

Some of the more curious phenomena of the granite formations may be illustrated to the eye more readily than explained in words. Fig. 1, Plate III, exhibits a granitic vein passing through a dark quartzose clay slate, dividing itself into branches and becoming finer in grain the more compactly it is pressed. Fig. 2 represents a strange interlacement of rocks observed in Glen Tilt, Perthshire. At the base (12) there is a red compact granite, above that limestone interveined in the lower part with red granite and white calcareous spar (11–9), but in the upper part with red granite alone. Over this there lie masses of hornblende (8) and quartz and felspar, and then laminated limestone with a red felspar vein piercing it (7). Overlaid on this there rest hornblendes and laminated felspar (6), and limestone laminated by red felspar and hornblende (1). The layer overlapping this consists of white quartz and red felspar crystallized (2); a felspathic ore interspersed with layers of black hornblende comes next (3), and limestone laminated with felspar constitutes the upper surface. Fig. 3 is a diagram of the venigenous masses of a Cornish clay-slate rock, provincially called *killas*, through which a coarse and porphyritic granite, having large crystals of felspar imbedded in it, is seen intermingling with and overlapping the schists, and altering the character of the slate through which it has made its way. Fig. 4 is a schistose section of Ben Cruachan traversed by veins of granite, which are themselves intersected by two dykes of differing porphyry. Figs. 5 to 9 are sectional diagrams of portions of the Salisbury Crags, Edinburgh, showing unstratified greenstone, inclosed by stratified sandstone, conglomerate, shale, and nodules of ironstone, in which both the igneous and sedimentary rocks are altered in their formation. Beside these we have placed on the same Plate, fig. 10, a horizontal plan of an interposed dyke, about 30 feet wide, on one of the western cliffs of Arran, in which, as the letters G, H, and P respectively indicate, greenstone, hornstone flint, pitchstone, are curiously disposed; fig. 11, which shows in a diagram of an ordinary mineral vein, in *b b*, a middle mass or continuous rib of *galena* (sulphide of lead); in *c c*, alternating bands of barytic spar, technically known in Derbyshire as *cawk* or Derbyshire spar—a fluoride of calcium; and in *d d*, the rocks which, inclosing the vein, form its walls; and fig. 12, is a "ridered" rock—*i.e.* one penetrated by what are termed strings, leading to or branching from metallic veins, as *v v* is seen to do towards *s s s*. Fig. 13 is a diagram illustrative of the phenomena of crossing in metallic [or other] veins arising from slips or dislocations of the strata in the fissures of which they occur, and the consequent displacement to which they are liable. The cross vein is represented by *a*; *b* shows a vertical vein, and *c* and *d* indicate two of the different type-forms of displacement which may occur should it be subjected to a vertical movement. A careful study of these various figures will greatly aid the mind in forming right ideas regarding the possible phenomena which geology brings under review as the results of change in the relations and the effects of the movements of various kinds of rock structures.

ALGEBRA.—CHAPTER V.

MULTIPLICATION AND DIVISION OF FRACTIONS.

THE multiplication of fractional quantities proceeds upon the same principles as have already been explained in regard to addition of fractions, although the form of the operation assumes a different appearance. The letters and symbols, of course, indicate the numbers and operations of arithmetic, and there cannot therefore be much difficulty in understanding the more general expression of those rules which govern them, when they are proved to hold good in those cases in which letters are employed to indicate any number we may choose to represent by them. For example, let it be given us to multiply any fractional quantity denoted by $\frac{a}{b}$ by a whole number—say the integer 7. It is quite plain that whatever quantity or magnitude is represented by $\frac{a}{b}$, the product given must be seven times as great. We know that $\frac{a}{b}\times 7$ must represent the quantity or magnitude $\frac{a}{b}$ seven times, *i.e.* must equal $\frac{7a}{b}$. To multiply a fraction, therefore, by an integer, we require merely to multiply the numerator by the whole number, and place the denominator below the line as the sign that the whole new numerator is to be divided by the former denominator. In the same way, if we are asked to multiply $\frac{a}{b}$ by c, we have $\frac{a}{b}\times c=\frac{ac}{b}$. Conversely $\frac{ac}{b}\div c$ will be $=\frac{a}{b}$.

Of course, to multiply the whole number 7 by the fraction $\frac{a}{b}$, *i.e.* $7\times\frac{a}{b}$, will give the same result as before, for $7\times a=7a$, which is to be divided by b, and the answer therefore is $\frac{7a}{b}$.

If, again, we have to multiply a fraction by a fraction, say $\frac{a}{b}\times\frac{c}{d}$, we require to multiply the numerators of the two fractions together for a new numerator, and their denominators for a new denominator, *i.e.* $\frac{a}{b}\times\frac{c}{d}=\frac{ac}{bd}$. For if we had had to multiply $\frac{a}{b}\times c$, the product would have been $\frac{ac}{b}$, but the quantity c, which is used as a multiplier, is also to be divided by d, *i.e.* into d parts, and this must be indicated in the product, as is done when we write $\frac{ac}{bd}$. In this case, as in the previous one, therefore, the multiplication of the one numerator by the other furnishes the new numerator, and the product of the one denominator multiplied into the other supplies the new denominator.

The foregoing question may be explained and worked in a different form, but equally correctly, thus:—

What is the product of $\frac{a}{b}\times\frac{c}{d}$? Let us assume that $p=\frac{a}{b}$ and $q=\frac{c}{d}$, then we proceed to multiply $p=\frac{a}{b}$ by b, and $q=\frac{c}{d}$ by d; the results are, of course, that $bp=a$, and $dq=c$. Now, the product of equal quantities must be equal quantities; therefore $bp\,.\,dq=a\,.\,c$, and dividing these equal quantities by bd, we obtain

$$pq=\frac{ac}{bd};\ \text{that is,}\ \frac{a}{b}\times\frac{c}{d}=\frac{ac}{bd},$$

the same answer precisely as was previously obtained.

If a mixed quantity be given to be multiplied, we must reduce the expression of it to an improper fraction. This we do by multiplying the integral part by the denominator, annexing the numerator with its proper sign prefixed, and writing, under the result, the denominator; *e.g.*

$$1+\frac{x}{a}=\frac{a+x}{a};\ 1-\frac{x}{a}=\frac{a-x}{a};\ \text{and}\ x+\frac{a^2-x^2}{a}=\frac{a^2-ax-x^2}{a}$$

When the numerators of the given fractions can be divided by any quantity which is common to each, the resulting quotients can be used instead of the originally given fractional factors, and if a fraction is to be multiplied by any quantity, it will come to quite the same when we multiply the numerator by that quantity, or when we divide the denominator by it; *e.g.*

$$\frac{a}{b}\times b=a;\ \frac{ad}{bc}\times c=\frac{ad}{b};\ \text{and}\ \frac{3x}{2}\times\frac{2x}{3}=x^2.$$

We must keep in mind that the value of a fraction does not depend on the absolute, but on the relative magnitudes of numerator and denominator, and therefore that the multiplication or division of both of the terms of a fraction by the same number makes no change in its real value. We know that $\frac{2}{3}, \frac{4}{6}, \frac{6}{9}$, and $\frac{8}{12}$ are expressions of equivalent values, and we are easily convinced that $\frac{m}{n}$ equals $\frac{am}{an}$, and that $\frac{ax+ay}{av+az}$ finds its equivalent in $\frac{x+y}{v+z}$, because every fraction is proportioned to unity exactly in the ratio of its numerator to its denominator. Hence (1) the multiplication of the numerator of any fraction is equivalent to the division of the denominator, and (2) the division of the numerator is in reality a multiplication of the denominator; for the same change as regards ratio is made by the multiplication of one of its terms as by the division of the other; *e.g.* $\frac{a\times d}{b}$, if we divide both its terms by d—which does not alter its value—becomes $\frac{a}{b\div d}$, and $\frac{a}{b\times d}$, when we divide both its terms by d, becomes $\frac{a\div d}{b}$.

When we multiply both terms of any fraction by the same number the ratio is unchanged, and the value of the fraction is not affected. It follows hence that the ratio of two fractions is the same as that of the products obtained by multiplying their numerators into their alternate denominators—as, $\frac{a}{b}$ is to $\frac{c}{d}$ as $a\times d$ is to $c\times b$, and their products become their numerator when reduced to the same denominator.

As in the case of multiplication, if a fraction is to be divided by an integer, or an integer by a fraction, we may either (1) divide the numerator by it, or (2) multiply the denominator by it; as, $\frac{1}{x}\div x=x$. Again, $a\div\frac{b}{c}=\frac{ac}{b}$, for $a=\frac{a}{1}$; now $\frac{a}{1}\div\frac{b}{c}=\frac{a}{1}\times\frac{c}{b}$, and this again yields the answer which was previously gained, viz. $\frac{ac}{b}$.

$$\text{Similarly,}\ \frac{12x}{5}\div 4x=\frac{1}{4x}\times\frac{12x}{5}=\frac{12x}{20x}=\frac{3}{5}.$$

Let the student follow out the operations and cancellations which occur in the following:—

$$\frac{a^2-x^2}{a}\times\frac{a}{a-x}\times\frac{a}{a+x}=a;\ +\frac{5a}{4x}+\frac{12b}{13x}=\frac{15ab}{13x^2};$$

$$a-\frac{x^2}{a}\times\frac{a}{x}+\frac{x}{a}=\frac{a^4+x^4}{a^2x};\ \frac{15x-30}{2x}\times\frac{3x^2}{5x-10}=\frac{9}{2}x;$$

$$\frac{(a-x)\,x}{a}\times\frac{ax}{a^2-x^2}=\frac{x}{1}\times\frac{x}{a+x}=\frac{x^2}{a+x}.$$

Having followed us intelligently thus far the student will be prepared to carry his thoughts along the succeeding processes of algebraical reasoning, which is intended to show the grounds upon which the multiplication of fractions proceeds in a simple manner, although from the necessarily technical language in which it is couched a careful attention to the phraseology employed will be requisite. That given, the apparently difficult and even somewhat uncouth and uninviting page will be found to be instructive and profitable.

We shall begin by supposing that the following query has been put before us:—

What is the product of $\frac{a}{b}$ by m? Let p be the value of the fraction $\frac{a}{b}$, so that $\frac{a}{b}=p$; then by the nature of division, as explained in Chapter III., pp. 344–346, $a=bp$; multiplying these equal quantities by m, we obtain $m.a=mb.p$; and, dividing the result by b, we find

$$\frac{m.a}{b}=m.p, \text{ which is } \frac{m.a}{b}=m.\frac{a}{b}, \text{ for } p=\frac{a}{b}.$$

From this formula it appears that to multiply a fraction by any integral quantity is really to multiply its numerator by that quantity. For example,

$$c\times\frac{a-1}{a+b} \text{ is } \frac{ac-c}{a+b}, \text{ and } (a+x)\times\frac{v}{x+y} \text{ is } \frac{av+vx}{x+y}.$$

The student will require to observe that when fractions are written side by side of integral quantities (and also, as we shall hereafter see, side by side of each other), multiplication is intended to be denoted; *e.g.*

The expression $a\,\frac{b}{c}$ means $a\times\frac{b}{c}$, and is equal to $\frac{ab}{c}$.

Again, $(a-c)\,\frac{x}{y}$ means $(a-c)\times\frac{x}{y}$, and is equal to $\frac{(a-c)x}{y}$.
Upon the same principle the student may now be able to show that $(a-c)\,\frac{x}{y}-(b+c)\,\frac{y}{x}=\frac{axx+byy-c(xx+yy)}{xy}$.

Let us now suppose that the fraction $\frac{a}{mb}$ has been given us, and let us be required to multiply its numerator by m; the result would be $\frac{ma}{mb}$, which is in reality, as before, $\frac{a}{b}$.

Therefore, $m\times\frac{a}{mb}$, which is $\frac{m\times a}{mb}$ is the same as $\frac{a}{mb\div m}$.

The foregoing examples prove that the result is the same whether the numerator of the fraction be multiplied by the given multiplier, or the denominator be divided by it. This may be easily shown thus:—

$$(1)\ a\left(\frac{a-1}{a-ab}\right)=\frac{a(a-1)}{a-ab}=\frac{a-1}{(a-ab)\div a}=\frac{a-1}{1-b}.$$

$$(2)\ (a+b)\left(\frac{x+2}{aa-bb}\right)=\frac{x+2}{x+b}, \text{ and } (x+y)\ \frac{a-x}{ax+ay}=\frac{a-x}{a}.$$

Let us, once more, have p given us to indicate the value of the fraction $\frac{a}{b}$, and let p require to be multiplied by m.

This gives $m.p$; but $m.p=p.m$; therefore $m.\frac{a}{b}=\frac{a}{b}\ .m$; but $m.\frac{a}{b}=\frac{ma}{b}$, consequently, $\frac{a}{b}.m$ is also $\frac{ma}{b}$. From this operation we see that the results of the multiplication of a fraction by a whole number, and of a whole number by a fraction, are in effect the same; that is, a times $\frac{a-1}{x+1}$ is the same as $\frac{a-1}{x+1}$ times a: both give $\frac{aa-a}{x+1}$; and $a+x$ times $\frac{a-x}{a+x}$ is $\frac{a-x}{a+x}$ times $a+x$: both give $a-x$.

As a consequence of the preceding reasoning, it appears that the fraction $\frac{ma}{b}$ may be either (1) $m.\frac{a}{b}$, or (2) $a.\frac{m}{b}$, or (3) $a.\frac{1}{b}\,m$, or (4) $m\,a\div b$; we are therefore entitled to conclude, generally, that multiplication and division may be changed in the order of their operation.

Hence $\frac{a+1}{b-a}(c-1)$ is $(a+1)\frac{c-1}{b-a}$, and may, as we have seen, also be written $(a+1)\,(c-1)\,\frac{1}{b-a}$.

It is obvious, therefore, that the product of two fractions is a fraction having for its numerator the product of the numerators, and for its denominator that of the denominators. As the product of any two fractions may be multiplied by a third fraction, and the result of these again by a fourth, and so on, this same rule may be considered as generally applicable to any number of fractions requiring to be multiplied together. It may be stated thus:—Multiply all the numerators together for a new numerator, and all the denominators together for a new denominator; as,

$$(1)\ \frac{a}{b}\times\frac{m}{n}\times\frac{p}{q}\times\frac{x}{y}=\frac{ampx}{bnqy};\ (2)\frac{m}{an}\times\frac{3bn}{2m}\times v=\frac{3bmnv}{2amn};$$

$$(3)\ \left(\frac{2}{a+b}\right)\left(\frac{a-b}{7}\right)=\frac{2a-2b}{7a+7b};\ (4)\ \frac{a}{b}\left(\frac{a}{b}-\frac{b}{c}\right)=\frac{aac-abb}{bbc}.$$

The actual process is often shortened by suppressing or cancelling, previous to performing the multiplication, all quantities common to the numerators and denominators of the given fractions, as in the following examples:—

$$(1)\ \frac{a}{y}\times\frac{x}{y}\times\frac{b}{x}\times\frac{y}{cx}=\frac{a}{1}\times\frac{1}{y}\times\frac{b}{x}\times\frac{1}{c}=\frac{ab}{cxy};$$

$$(2)\ \left(\frac{a+b}{a-b}\right)\left(\frac{a-b}{a+b}\right)=1;\quad t\left(\frac{a-x}{m}\right)\left(\frac{1}{a-x}\right)=\frac{t}{m}.$$

As a safeguard to the student in working out exercises, it may be advisable to remark that when a fraction has the sign $-$ prefixed the meaning is that the whole result of the fraction is to be subtracted. When the denominator is removed, it must therefore be remembered that the sign which was placed before the complete fraction now belongs to the complete numerator. When the numerator consists of several terms—the only case in which error can arise—it is generally advisable to place it within brackets until the operation of subtraction has been actually effected. The following example will show what we mean, and may be helpful:—

$$\text{Multiply } \frac{3x-1}{4}-\frac{a-x}{5}-\frac{2x-2a}{3}-\frac{xx+b-c}{8} \text{ by } 120.$$

The operation may be performed as follows:—

$$\frac{120}{4}(3x-1)-\frac{120}{5}(a-x)-\frac{120}{3}(2x-2a)-\frac{120}{8}(xx+b-c);$$

that is, $30\,(3x-1)-24(a-x)-40(2x-2a)-15\,(xx+b-c)$; or $90x-30-24a+24x-80x+80a-15xx-15b+15c$, and, by reduction, $56a-15b+15c+34x-15xx-30$.

ASTRONOMY.—CHAPTER VII.

SATURN — PERIOD — COMPRESSION — ITS BELTS — COLOUR — SPOTS — PROBABLE ATMOSPHERE — RING — DUSKY RING — DISCOVERY OF RING BY HUYGHENS — ROTATION OF RING — ECCENTRICITY OF RING — MEASUREMENTS OF RING — SHADOWS THROWN BY RING — SATELLITES OF SATURN — PECULIARITIES OF IAPETUS—AMOUNT OF LIGHT RECEIVED FROM SUN — MASS OF SATURN — URANUS — CIRCUMSTANCES CONNECTED WITH ITS DISCOVERY—PERIOD—EARLY OBSERVATIONS — PHYSICAL APPEARANCES — LIGHT RECEIVED FROM SUN—SATELLITES—THEIR RETROGRADE MOTION—MASS OF URANUS—NEPTUNE—HISTORY OF ITS DISCOVERY BY ADAMS AND LE VERRIER—PERIOD—PHYSICAL APPEARANCES — ECCENTRICITY OF ORBIT — SATELLITE — RETROGRADE MOTION—MASS OF NEPTUNE.

SATURN. ♄

ALTHOUGH inferior in size to Jupiter, Saturn is the most interesting planet of the solar system. It revolves round the sun in 10759·2 days or 29·45 years, at a mean distance of 872,134,000 miles, which an eccentricity in its orbit of 0·056 increases to 921,105,000 miles, or diminishes to 823,164,000 miles. Its apparent diameter varies between 14·6″ in conjunction, and 20·3″ in opposition, and its real equatorial diameter may be taken at 71,904 miles. Its polar compression is larger than that of any other planet, Jupiter not

excepted; but on account of the ring, the most remarkable feature of this planet (see Plate II.), distracting the eye, it is less noticeable than that of Jupiter. Herschel values the compression at 1-10·34; Bessel at 1-10·19; and Hind at 1-9·02. Saturn has no perceptible phases. The figure of its mass is that of an oblate spheriod. As in the case of Jupiter, only the outline of Saturn's atmosphere is seen, and not that of the body of the planet itself. Belts are observed on Saturn resembling those of Jupiter, but very much fainter, and they are probably of the same physical character. The planet's ordinary colour is yellowish-white, the belts inclining to grayish-white. A powerful telescope will, however, show considerable diversity of colour on Saturn, and a marked distinction between the yellow tint of the body of the planet and the bluish-white hue of ring B.

The belts of Saturn differ from those of Jupiter in the respect that they exhibit at times a sensible curvature, while those of Jupiter are rectilinear; from this circumstance it is inferred that the plane of the planet's equator must make a considerable angle with the ecliptic. Herschel fixes the period of the planet's axial rotation at 10 hrs. 29 min. 16·8 sec. Spots on Saturn are very rare. Herschel considers that there are decided indications of the existence of an atmosphere, the satellites when undergoing occultation by the planet's body never disappearing instantaneously. An examination of the polar regions shows that according as they were turned towards or from the sun a difference of hue was perceptible, which may reasonably be supposed to be due to snow in those regions melting under the sun's rays, and accumulating in the absence of those rays, as in the case of Mars already noticed.

The existence of more than two rings surrounding Saturn is now certain, and the system of rings must therefore be considered a *multiple* one, and a subdivision of the exterior ring is generally accepted. The discovery in 1850 by Bond of an interior *dusky ring* between the inner ring and the planet is a curious and interesting feature, and this dusky ring has been observed to be divided into two or more concentric rings. The transparency of the dusky ring was established by Jacob, Dawes, and Lassell in 1852. The honour of the discovery of the rings of Saturn is due to Huyghens in 1659, who seems to have spent several years in observing the planet before he decided that the theory of a ring round the planet was the only one which would reconcile the various observed facts; and to commend his hypothesis to the attention of astronomers, Huyghens predicted that in the month of July or August, 1671, the planet would once more appear round, the appearance of the ring having disappeared. In this prediction he was nearly correct, for Cassini, watching the disappearance of the ring, found the planet presenting this aspect in May, 1671, or within two months of the period predicted by Huyghens.

The improvement in the telescope has now greatly increased the knowledge of the Saturnian system. The true form of the rings appears to be circular or nearly so, but as they are always viewed foreshortened, they appear more or less oval when the Earth is above or below the plane of the rings, but when the Earth is nearly in the same plane they appear as a single straight line. When the Earth is exactly in the plane they disappear altogether, except in telescopes of the highest power. In the true position of the rings during the planet's revolution round the Sun there is no change; they remain continually parallel to each other. The plane of the rings is inclined 28° 10′ to the ecliptic; and whether viewed from the Earth or from the Sun, the phenomena seen in connection with the rings of Saturn are much the same, but the motion of the Earth in its orbit, the inclination of which differs somewhat from that of Saturn, gives rise to certain phases in the rings which would not be witnessed by an observer placed on the Sun. Saturn's period of revolution being 29·458 years, the half of this, or 14·729 years, will be the average period elapsing between two nodal passages or the points in the orbit of the planet where it intersects the plane of the ecliptic. Such a passage took place in 1862. The southern surface of the ring had then been visible for 14·7 years. On 31st January, 1862, the Sun, passing through the plane of the ring, began to illuminate its northern surface, and the Earth being also on that side, the ring reappeared. On 17th May the Earth went to the south, and the Sun remaining on the north, a disappearance of the ring took place. The ring remained invisible, in consequence of presenting its unilluminated side to the Earth till 12th August, 1862, when the Earth, passing through the plane of the ring to the north, brought the northern side into view, which remained so up to 1877. The greatest opening out of the ring occurred in August, 1869, the planet being in 257·5° lon., and the last great opening out of the ring occurred in June, 1885, with the planet in 77·5° lon. From careful examination of the ring, Sir W. Herschel ascertained that it revolved round the ball of the planet in 10 hrs. 32 min. 15 sec., a period not greatly in excess of that of the planet's own axial rotation, the direction being the same in both cases. There are, however, difficulties in the way of accepting this rotation. In 1854–56 Secchi made numerous measurements of the rings, but found they varied considerably, and also that while those of two consecutive days did not harmonize, those of three and nine days agreed; and the idea then occurred to him that the results might be explained by supposing the ring to be elliptical, presenting sometimes its longer, and sometimes its shorter diameter. He was unable to confirm Herschel's period of rotation with his own observations, but found that a period which corresponds with that which a satellite placed on the margin of the ring would have, namely 14 hrs. 23 min. 18 sec., would satisfy them. Otto Struve some years since introduced a system for distinguishing the rings from each other, which is now generally adopted. The exterior bright ring he called A, the interior bright ring B, and the dusky ring C. When reference is made to the whole system, it is usual to speak of the "ring" in the singular number. The ring is not concentric with the ball. Gallet of Avignon announced this in 1664, placing the ball nearer to the east extremity of the ring as viewed from the Earth. In 1827, Schwabe confirmed the eccentricity of the ring, but gave it in the opposite direction to that assigned by Gallet. Struve found that at the mean distance of Saturn from the Earth, while the diameter of the eastern vacuity or space between the planet's body and the ring was 11·288″, that of the western was only 11·073″, showing a difference in favour of the former of 0·215″. This peculiarity has been shown to be essential to the stability of the rings; without this feature and without rotation they would fall upon the planet. The following measurements in mean distance from the planet are given by Schwabe:—

Outer diameter of exterior ring,	. .	169,530 miles.
Inner diameter "	. .	149,210 "
Breadth "	. .	10,160 "
Outer diameter of interior ring,	. .	145,768 "
Inner diameter "	. .	112,758 "
Breadth "	. .	16,503 "
Interval between the two,	. .	1,725 "
Distance of ring from ball,	. .	18,346 "
Equatorial diameter of ball,	. .	74,417 "

Herschel estimated the thickness of the rings at not more than 250 miles; Bond at only 40 miles. Peirce considered that there were good grounds for supposing the rings to be fluid; but it is now generally considered that they are a dense aggregation of small satellites, densest where brightest, and widest apart where most faint. Indeed, it may be demonstrated, that if a system of rings of such proportions were constructed of iron, it must become semi-fluid under the forces it would experience. Considered as a system, the rings are sensibly more luminous than the planet, and B is brighter than A. When at its nodes the ring frequently appears broken, showing merely luminous elongated beads seemingly detached from one another. This appearance is caused by the concurrent effect of light reflected by the edges, external and internal, of the rings. The rings are observed to cast a shadow on the planet; in general the brightness of the ball and of the rings is tolerably uniform, but at times there are variations, probably arising from optical effects, and not dependent on actual change. Bessel, by observing the perturbing effect of the rings on the orbit of the sixth satellite, Titan, estimated its mass at $\frac{1}{118}$ of the mass of the planet. The thickness of the rings being too small for measurement, no

accurate determination of their density is attainable; if it is assumed to be equal to the mass of the planet, which is not improbable, the thickness would be about 138 miles, nearly the mean of the two estimates of Herschel and Bond. Saturn is attended by eight satellites, *Mimas*, *Enceladus*, *Tethys*, *Dione*, *Rhea*, *Titan*, *Hyperion*, *Iapetus*, seven of which move in the orbits whose planes coincide nearly with that of the planet's equator, and therefore with the plane of the rings also. The orbit of the most distant satellite is inclined about 12° 14′ to the plane of the equator.

In consequence of this coincidence in the orbits of the first seven satellites, if the planet is inhabited they will always be visible from both hemispheres when not under eclipse in the planet's shadow. From the small apparent size of most of these satellites, the largest of which does not exceed 3300 miles in diameter, and the smallest some 500 miles, it is very difficult to attain an accurate knowledge of their motions. Celestial phenomena, as viewed from Saturn, would possess extreme magnificence, the rings forming a series of arches stretched across the Saturnian heavens. Considering the immense distance of Saturn from the sun, its satellites form an important factor in the Saturnian sky as reflectors of sunlight. The area occupied by all of them taken together, is estimated at about six times that covered by the moon. The only physical fact yet discovered in relation to the satellites of Saturn, is that one of them, Iapetus, experiences a considerable loss of light when traversing the eastern half of its orbit. The conclusions arrived at from this circumstance are, that the satellite rotates once on its axis in the same time that it performs one revolution round the planet; and that there are portions of its surface which are almost incapable of reflecting the solar rays. The mass of Saturn has been variously estimated. Newton gives it as $\frac{1}{3021}$; Laplace, $\frac{1}{3359}$; Bouvard, $\frac{1}{3512}$; and Bessel at $\frac{1}{3500 \cdot 5}$. The Sun, as viewed from Saturn, would only appear about 3′ in diameter, and the greatest elongations of the orbits of the planets Mercury, 2° 19′; Venus, 4° 21′; Earth, 6° 1′; Mars, 9° 11′; Jupiter, 33° 3′; so that an observer on Saturn would only be able to distinguish with the naked eye Jupiter, Uranus, and Neptune; and Mars by the aid of a telescope: the Earth would not be visible. Saturn, on account of its apparent slow pace, was selected by the alchemists as the symbol for lead. In computing the positions of Saturn the tables of Le Verrier are used. Tables of the satellites are as yet unformed.

URANUS. ♅

The planet Uranus, situated at a distance from the sun beyond the orbit of Saturn, was first observed in March, 1781, by Sir W. Herschel, as a small star, in the vicinity of the star H Geminorum, in the constellation Gemini, and by employing higher magnifying powers he found its apparent diameter to increase very considerably, a circumstance which conclusively proved that it was not a star, as the fixed stars under the highest powers only present points of light. Continued observation detected a motion at the rate of 2½″ per hour, and from this circumstance Herschel conjectured the object to be a comet, and made an announcement to that effect to the Royal Society on 26th April, 1781. Four days after its first discovery it was observed by Maskelyne, the astronomer-royal at that time, who appeared from the first to have suspected its planetary character, and in two or three months it became the subject of observation in all the leading European observatories. The final determination of its motion was only arrived at step by step, and the credit of first announcing with any degree of certainty that it revolved round the sun in an orbit nearly circular, and that it was a planet and not a comet, is due to Lexell. A careful inspection of the labours of former astronomers showed that Uranus had been observed and recorded as a fixed star, at least, on twenty previous occasions; as early at 1690 by Flamsteed, who recorded it several times; by Bradley in 1748, and by Le Monnier in 1750, who recorded it no less than twelve times. All these early observations have been of great service in determining the elements of the planet's orbit. Uranus revolves round the sun in 30,686·7 days, or rather more than eighty-four years, at a mean distance of 1,753,851,000 miles. The eccentricity of its orbit amounts to 0·04667, which is rather less than that of Jupiter's. At its greatest distance from the sun, it is 1,835,700,000 miles, and its nearest approach is 1,672,001,000 miles. The apparent diameter of Uranus, as seen from the earth, varies but slightly; and its mean value is about 3·9″. The real diameter is about 33,000 miles. No comparison has as yet been determined, though Arago has pointed out that a polar compression may exist, but not be always visible, because a spheroid, when viewed in the direction of its axis, necessarily presents a perfectly circular outline. It has been calculated that the amount of light received by Uranus from the Sun is equal to that which would be afforded by 300 full moons. An observer placed on Uranus could see Saturn, and perhaps Jupiter, but none of the planets included between Jupiter and the sun. The disc of Uranus appears uniformly bright, and exhibits neither belts nor spots. Its period of axial rotation is unknown, but by analogy it may not differ materially from that of Jupiter or Saturn. Uranus is just visible to the naked eye when in opposition, if the observer knows its precise position. The inclination of the planet's axis is undetermined. Uranus is known to be attended by at least four satellites, *Ariel*, *Umbriel*, *Titania*, *Oberon*, two of which were discovered by Herschel, and two by recent observers, Lassell and Struve; but such is their extreme minuteness that only the most powerful telescopes discover them. Their chief peculiarity is the inclination of their orbits, which for direct motion amounts to 101°; or, in other words, their Uranicentre motion is retrograde, the planes of the orbits lying nearly perpendicular to the planet's ecliptic. The mass of Uranus is variously computed. It is generally stated to be about $\frac{1}{24516}$, which is the figure given by Mädler. The tables used for computing the places of Uranus are those completed in 1872 by the American astronomer, Newcomb.

NEPTUNE. ♆

The discovery of the planet Neptune, the most distant one of the solar system, is a remarkable circumstance in astronomical science. More than sixty years since the French astronomer Bouvard made a very careful investigation of the motion of Uranus, for the purpose of preparing tables of the planet. In working up the various observations by Flamsteed and others, subsequent to the direct optical discovery of Uranus in 1781, he found himself able to assign an ellipse harmonizing with the first series, and also one harmonizing with the second; but by no possibility could he obtain an orbit which was reconcilable with both. In consequence Bouvard decided to reject all the earlier observations, and to adopt solely those of the more recent dates. By this means he was able to produce tables of the planet which fairly represented its motion in the heavens. In a few years, however, discrepancies appeared between the tables and the motions of the planet of so marked a character, that some cause other than any legitimate error in the tables evidently existed; and Bouvard himself, who died in 1840, appears to have conceived that an exterior planet was alone the cause of the irregularities existing in the motion of Uranus. This view of the matter was generally accepted by astronomers. In 1843 Mr. J. C. Adams of St. John's College, Cambridge, determined to investigate the matter of the hypothesis of an exterior planet, and after one and three quarter year's labour, in October, 1845, forwarded to Airy provisional elements for a planet revolving round the sun at such a distance, and of such a mass as he considered would satisfy the observed perturbations of Uranus. This was virtually a solution of the problem in a theoretical point of view, although at the time the result was not made public. The French astronomer Le Verrier of Paris, in the summer of 1845, also investigated the anomalous movements of Uranus, and in the November of that year issued his first memoir, showing that they did not depend solely upon the attractions of Jupiter and Saturn. In June, 1846, Le Verrier published his second memoir to prove that an exterior planet was the cause of the residual disturbance, and assigned elements for it in the same way that Adams had done eight months before. The two sets of elements were found to agree in so remarkable a manner, that Airy suggested to Professor Challis, of Cambridge, to

employ the large Northumberland telescope in search for the supposed planet. On 29th September the new planet was found. In August Le Verrier published a third memoir, containing revised elements, and further observations placed it beyond a doubt that the eighth-magnitude star observed was in reality the trans-Uranian planet. This brilliant discovery, the grandest of which astronomy can boast, will be best appreciated, so far as the general reader is concerned, by placing in juxtaposition the observed longitude of the new planet when telescopically discovered, and the computed longitudes of Adams and Le Verrier:

Longitude of Neptune as observed, .	326° 52′.
Computed by Adams, ...	329° 19′.
Computed by Le Verrier, ...	326° 0′.

Neptune revolves round the sun in 60,126 days, or 164·6 years, at a mean distance of 2,746,271,000, which an eccentricity of 0·0087 increases to 2,770,217,000 miles maximum distance, or diminishes to 2,722,325,000 miles. The apparent diameter of Neptune only varies between 2·6″ and 2·8″. Its real diameter is about 36,600 miles, a diameter somewhat greater than that of Uranus. No compression has as yet been observed. Neptune is destitute of visible spots and belts, and the period of its axial rotation is unknown. Neptune is known to be attended by one satellite, discovered in 1846 by Lassell, and revolving round the planet at a mean distance of 220,000 miles. The motion of this satellite is retrograde, a circumstance which, except in the case of the Uranian satellites, is without parallel in the solar system as regards planets, though there are many instances of retrograde comets. The mass of Neptune is variously estimated. Struve gives it as $\frac{1}{14494}$, Bond as $\frac{1}{19400}$, Hind as $\frac{1}{17900}$, Mädler as $\frac{1}{14455}$; and Safford (the most recent estimate), as $\frac{1}{20039}$. Owing to its immense distance from the sun, only Saturn and Uranus could be seen from Neptune were an observer placed on that planet.

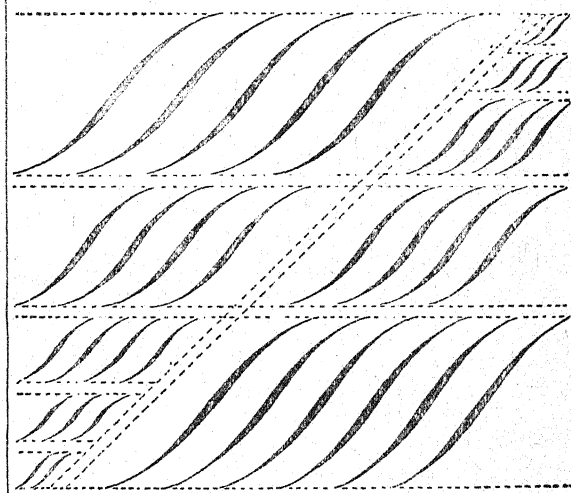
PENMANSHIP.—CHAPTER VI.

CAPITALS HAVING GRACE-LINES AND OVALS, WITH ANALYSIS OF THEIR ELEMENTS.

GRACE of form is pleasant to the eye and gratifying to the mind. The love of the beautiful is widespread, and the delight felt in looking upon loveliness of outline and contour is vivid and inspiriting. The useful is agreeable, the beautiful is exquisite. When to the useful beauty is added, a charm which captivates indicates the attractiveness of the union. In penmanship, as an agency for the registration and transmission of knowledge, sentiment, and thought, one quality beyond all others is imperatively required—legibility. But the acquisition of a good, general, easily-read, current style of writing, though it may be all that is necessary and indispensable, is not all that is desirable. The mere linear execution of an exercise in writing may be done with absolutely faultless neatness, and yet be wanting in that pleasant sweetness of appearance, slope, pliancy, and sweep which indicate the thorough mastery of the principles of grace. Ability to write a large, plain, bold, neat, legible hand ought to be diligently aimed at; but the persistent perseverance required for the attainment of that power need not end when that is successfully achieved, and it can be said, of each letter, that it is

"Made all aright by rule most absolute."

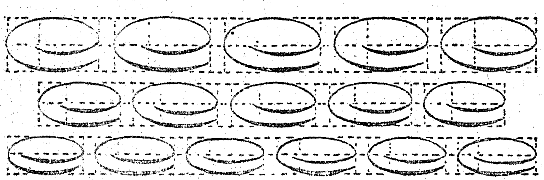
A continuance in well-doing will soon enable the earnest practitioner to add elegance and grace to correctness and proportion of form. It is easier, however, to carry with us through all our efforts the ideal of grace, and to aim at interpenetrating all we do with it, than to regard it as an after-aim for subsequent endeavour and accomplishment. Though we have presented in our Plates on penmanship precisely classified specimens of letter-forms sufficient to supply instruction in a systematic way in all that is essential to legible writing, we have also set before the student a set of "flowing grace capitals" possessing considerable elegance and requiring for their proper execution some readiness and dexterity of muscular power, and some taste and skill in producing smooth, flowing, and pleasing curvilinear forms. On looking at the lower division of Plate II., the student will perceive at once the superiority in fairness of form of the classified alphabet shown there as compared with the one supplied in the upper half of the same Plate. In the larger proportion of them it will be seen that the Hogarthian grace-line appears conspicuously, and that in many also the oval—which presents a specially pleasing form—has a distinct place. In the six letters occupying the first line, and representing, in the order named, I, T, F, P, B, and R, these two type-forms prevail. The main or stem grace-line is in each Hogarthian in its serpentine sinuosity and subtle pliancy That specific line is not only the chief and primary element of each of these letters, but the guide to and the index of their beauty. If the writer fixes his mind on this peculiar part and discerns clearly (1) the speciality of its slope, (2) the precise union-point of the alternating curves, and (3) the gradation of the shading of the line as a whole, he should be able easily to reproduce that grace-line harmoniously and effectively. It is of great importance that this should be done, as upon the elegance and proportionateness with which this main-line is produced the character of the whole letter depends. To acquire such a caligraphic mastery over this specific line as to be able to produce it, with unerring accuracy, of any length that may be requisite, demands care, skill, and perseverance.



This may be practically set about by taking a sheet of paper, and after ruling it somewhat in the style shown above, making the length of the lines of as many differing proportions as may be desirable, and then proceeding to fill up the sheet with grace-lines from large to small, decreasingly, on the left-hand division, and, on the right, from small to large increasingly. The grace-line stem should be begun at about three and a half times the height of the small letters, which [are to] form the body of the writing. It is taken down with a curve convex towards the left for one-half of the entire length, and when that point is reached, but without any rest or stop, it is to be changed into a curve convex towards the right and carried along to the base-line, where a broad sweeping turn is to be taken upwards, and, also without stopping, run on into the formation of the terminal oval. The shading of the stem commences at the lower half of the upper curve, and goes on to the middle of the lower curve, thickening gradually till the junction of the curves is reached, and thinning gradually in the first half of the lower curve. It will therefore have its widest part or greatest thickness just at the point of junction. Some caligraphists, however, prefer making the shading occupy only the lower curve to the right, as doing so provides, they think, a more convenient place for the application of the requisite pressure. In forming this line, the pen should be held lightly, not grasped tightly, and the whole hand ought to move freely and nimbly. The lower half of the line should be precisely the reverse of the upper. The movement should be uniform in its sweep, and the line ought to be immediately formed by one down-stroke of the

pen. The importance of bestowing painstaking care on acquiring facility in the formation of this grace-line will be seen at once, when it is observed that it occupies a chief place in nearly two-thirds of the whole collection of letters.

Unfortunately, teaching, to be effective, requires to proceed by analysis, and that involves the fixing of the entire attention on each part separately, however intimate their union may be and ought to be in the complete whole. Had it not been so, we should have pointedly made our description of this main grace-line include the terminal oval. That, however, is the next element to be attended to. This oval begins on the base-line, just where the lower curve, having joined that line, would naturally show a tendency to rise. There the curve runs into [and ought to be uninterruptedly continued so as to form] the oval with which the line is terminated, and of which it forms a part. This terminal oval requires considerable care to keep it from showing any angular appearance, arising either from stoppage between the forming of the line and the oval, or from making any rapid change of curvature in the course of the elliptical sweep. Perhaps the best method of acquiring a correct and manageable idea of this specific oval is to rule a piece of paper with lines of varying depth as regards distance, and divide these ruled lines into distinct divisions, into each of which we may place [or suppose to be placed] two lines, arranged like the inner frame of a child's kite—the long intervening horizontal line being about one-half longer than the distance of the ruled lines, and being crossed by a perpendicular line touching these ruled lines on either side. Making a beginning at about one-eighth of the space-length, (1) proceed to form an elongated curved line



to the left, carrying it, in its course upward, a half width; (2) make along the upper half an inverse line constituting two arcs of an ellipse, and (3) bring it down to the half width indicated by the longer of the two inserted lines, and then (4) carry the line round parallel to that made on the base-line until the junction of the crossing interlines is reached. It will afterwards be advisable to practise the taking of the whole grace-line and oval in one sweep, giving special care in doing so not to hesitate in the forming of the oval curve; for if that be done it is sure to occasion an unsightly angularity in the elliptical part of the line, on the due curvature of which the elegance of the oval so much depends.

The practice thus gained in forming elliptical lines, will simplify the operations required to finish off the individual letters. The addition of three-fourths of an oval, slightly elongated at the upper end, where it joins the grace-line, completes the I. Seven-eighths of a small oval running off into a nearly horizontal grace-line, and crossing the main stem-line as if balanced on the top of it, having two-thirds of its length on the left side, form the letter T. Through the midst of the main-stem in the form of T, a small grace-line ending in a loop gives F. The upper portions of P, B, and R are precisely similar, and consist of an elliptical form, interrupted in the under side, so placed that two-thirds of it or thereby is on the left of the main line, and the other third, being carried across the grace-line, is brought round so as nearly to touch it, and turned off with a small upward curvilinear sweep. In the case of P this is enough. In B, besides (1) the main grace-line and (2) this ovalesque heading, there is added (3) an almost perpendicular ellipsis looped on to the ovalesque head, and occupying the space between it and the base-line. In R there is looped on to the heading on the right a form similar to the second part of a small letter *n*, which on reaching the base-line takes an oval ornamental sweep, when the letter stands alone; but if it is joined to following letters it retains its usual plain upward semi-oval turn.

It will easily be understood that these somewhat tedious endeavours at describing things so simple, are rather intended to guide the student in his analytical survey of these letters with the Plate before him, than as directions to be implicitly followed without this illustrative aid. It often happens that the very simplicity of the things we are accustomed to see in nature and in art makes any attempt to give, in descriptive detail, an accurately expressed idea of them, seem, and probably be, "weary, stale, flat, and unprofitable." Words which run trippingly from the tongue, often appear, when duly set before the eye, tediously prolix. This we can scarcely hope to have avoided, though we have diligently abstained from presenting to the student any unnecessary descriptive term, and may, we fear, from mere familiarity of form, have left some element unnoticed in our current explanation.

NATURAL PHILOSOPHY.—CHAPTER XIII.

AIR-PUMPS—SPRENGEL'S PUMP—AIR-GAUGES—CONDENSING SYRINGE—PNEUMATIC DISPATCH—PNEUMATIC RAILWAY—AIR-CONDENSING ENGINE—FORGE BELLOWS—MECHANICAL FOG-HORNS—SUCTION-PUMP—FORCING-PUMP—FIRE-ENGINE—LIFTING-PUMP—DIVING BELL—AIR-GUN—ANEMOMETERS—APPLICATIONS OF HYDRODYNAMICS.

The two laws which have been established in connection with gases—namely, that air is a heavy elastic fluid, and that the density of a gas varies with its pressure—serve to explain most of the phenomena exhibited by gases at constant temperatures and the action of a great variety of pneumatic instruments. The suction of air from an inclosed vessel is the same mechanical operation as that of pumping water. The common pump does the work simply by exhausting air until the water rises by atmospheric pressure, and the ordinary air-pump is the same apparatus as a suction pump, the difference consisting mainly in the construction of the valves and more accurate fitting of the parts of the apparatus. The *air-pump* is therefore an instrument by which a vacuum can be produced in a given space, or by which air can be greatly rarefied, as an absolute vacuum cannot be obtained by its means. It was invented by Otto Guericke in 1650, shortly after the invention of the barometer. In the air-pump it becomes necessary to counterbalance or remove the pressure of the air on the upper surface of the piston, otherwise the labour of working the air-pump would be considerable. This may be ascertained by attempting to draw up a piston, 6 inches in diameter, from the bottom of an open cylinder into which it fits closely. The area of the piston being 28·27 square inches, a force exceeding 415 lbs. would be required to raise it. In all air-pumps the pressure of the air above the piston would be 14·7 lbs. on the square inch, and that below the piston in the cylinder would soon, by the action of pumping, be reduced to less than 1 lb., so that the atmosphere would oppose the ascent of the piston by a pressure exceeding 14 lbs. on the square inch, and would afterwards cause the piston to descend with the force of a violent blow. The force of this descent is therefore regulated by the exhaustion or diminished pressure of the air upon the under side of the piston. Upon this principle the coining presses at the Royal Mint were for many years worked. The force of the blow required to impress a steel die upon a blank piece of metal is much greater for the coining of a sovereign than for that of a threepenny piece; the piston imparting the blow was therefore raised through a cylinder in one direction against the full pressure of the atmosphere, and then suddenly set free; the returned force of the blow was regulated by the opposing resistance of the diminished air pressure within the cylinder, so that the recoil depended upon the degree of exhaustion of the air, which could be regulated with the greatest nicety to the requirements of the coinage. In the coining process now adopted at the Mint, the impress of the blank piece of metal is effected by a powerful squeezing action between two steel dies; the lower die is fixed on a bed of iron, and the blank being laid in position upon it, the upper die is brought down by the straightening of a toggle joint. The exact interval between the dies at the moment of impressing the coin is regulated by a steel wedge set in position by a regulating screw. The ordinary form of air-pump is shown in elevation and section (Plate XII.)

Smeaton's air-pump (fig. 3) consists of a hollow cylinder E, shown in section (fig. 4), communicating with a receiver A by a tube *f*. There are three air valves: one at the bottom of the cylinder, at *e*, another in the piston, and a third at the top of the cylinder, at *g*. When the piston moves from the bottom to the top of the cylinder—that is, from E to D—the centre valve closes; but the other two valves, top and bottom, open, and the air from the receiver A rushes into the lower part of the cylinder through the bottom valve *e*, while the air in the cylinder above the piston is expelled through the upper valve *g*. When the piston descends the valves *g* and *e* close, while the centre valve in the piston opens, and the air in the cylinder is forced through it ready to be drawn out on the next elevation of the piston. Thus the piston is relieved from the pressure of the external atmosphere by the upper valve *g* on the cylinder. The air-pump valve is made of a small strip of oiled silk stretched over a hole in a plate, and tied round with a thread. The silk strip is lifted by the air sufficiently to allow of its escape; but when the silk is pressed on the plate of the valve, the valve is perfectly closed. If A be the volume of the receiver, B the volume of the cylinder, p^1, p^2, p^3, the densities of the air in the receiver after 1, 2, 3 strokes respectively, then $p^1 (A+B)=pA$, $p^2 (A+B)=p^1A$, and so on; therefore $p^1, p^2, p^3 (A+B)^3=pp^1p^2A^3$, therefore $p^3 (A+B)^3=pA^3$. If this goes on for n strokes, then $p^n(A+B)^n =pA^n$, which gives the density or pressure of the air in the receiver after n strokes.

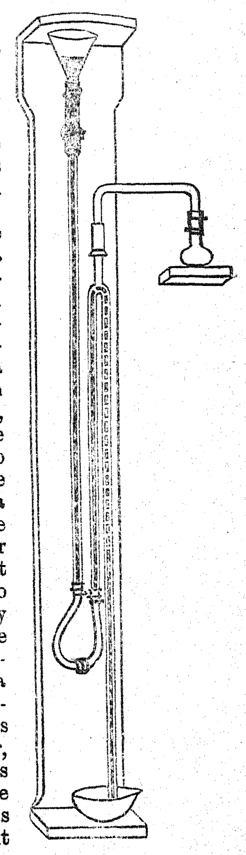
Hawksbee's air-pump is the form most commonly in use; it consists (figs. 1 and 2) of two cylinders *aa*, *aa*, placed side by side, but open at the top to the external air. The air pressure is nearly the same on both pistons, which are furnished with valves, as in Smeaton's air-pump, and the piston-rods are worked by a pinion placed between them and gearing with a rack *c*, *c*, on each piston-rod. As one piston rises the other descends, so that the atmospheric pressure is counterbalanced, and the exhaustion of the air from the receiver *k* by the pipe *h* is very rapid, but not very perfect, for the valves in the pistons will soon fail to open, on account of the pressure of the external air overcoming that in the valve passages. In the action of all air-pumps the air rushes from the receiver into the pump barrel, and follows the piston during the stroke. A mass of air cannot, however, move without the expenditure of heat, and the heat necessary for its motion is taken from the air itself. Therefore the air in the receiver of the air-pump is chilled during the exhaustion, and a cloud of vapour is formed inside the receiver during the first few strokes. If the air be charged with moisture a very striking effect is produced.

Grove's air-pump has only one valve, opening outwards at the top of the cylinder, and besides being more simple in construction is more perfect in the vacuum obtained. The tube from the receiver is brought to a point in the side of the cylinder somewhat nearer the bottom, by which means a solid piston does the work of pumping. The exhaustion is effected by passing the piston below the opening of the tube in the side of the cylinder; the air in the receiver fills the space between the depressed piston and the top of the cylinder; on the return stroke this inclosed portion of air is swept out of the cylinder, escaping by the valve. The exhaustion will go on until the air compressed in the cylinder becomes unable to raise the valve.

Tate's air-pump combines the advantage of double action with a single barrel, and is an improvement upon Grove's principle. The barrel is generally horizontal, and communicates with the receiver by a vertical opening in the centre of its length. The piston occupies a little less than half the length of the barrel, and consists generally of two discs rigidly connected together by the piston-rod which unites both. The barrel is furnished with two valves at either end of it, opening outwards. When the piston is driven down, the air from the receiver, entering by the central hole in the side of the barrel is expelled through the end valve, and on the return of the piston that valve closes, and the air in front of the piston is expelled through the other valve. In this way a certain volume of air, equal to about half the contents of the barrel, will be removed at each stroke of the piston; and as the difference of pressure at the two ends of the piston decreases with every stroke, the working of the pump becomes easier as the exhaustion of the air increases.

In Deleuil's air-pump the piston is of considerable length, and consists of a series of accurately constructed metal discs bolted together. The piston works easily and smoothly in the barrel, and neither packing nor lubrication is required, as the air in the space between the piston and the barrel acts as the lubricator. The internal friction of the air in this confined space is so great that the rate at which it leaks into the barrel is far less than the rate at which the pump exhausts the air from the receiver. This pump works very satisfactorily up to a considerable degree of exhaustion.

The most perfect air-pump is that devised by Sprengel, which depends on the principle of converting the space to be exhausted into a Torricellian vacuum. When an aperture is made at the top of a barometer tube, the mercury sinks and draws in air. If it be so arranged as to allow air to enter along with mercury, and if the supply of air be limited while that of mercury is unlimited, the air will be carried away and a vacuum produced. The most simple form of the Sprengel pump consists of a glass tube longer than a barometer tube, open at both ends. At the upper end a funnel is connected by means of a short india-rubber tube, and supported by a stand in a vertical position. When the funnel is filled with mercury, the fluid is allowed to fall into the tube at a rate regulated by a clamp pressure on the elastic tube; the lower end of the tube fits into a flask, which has a spout at the side a little higher up than the lower end of the tube. The upper part of the glass tube has a branch, to which a receiver can be tightly fixed. When the clamp pressure at the funnel is loosened, the mercury flows down the tube in a series of drops or cylinders separated by an interval, and as one has passed the opening of the receiver, the air in the receiver expands into the next space between the drops; this small portion of air is immediately cut off by the next following drop, and can never return, being carried down the tube with the mercury. Thus the whole length of the tube is filled with cylinders of air and mercury having a downward motion, and the receiver is exhausted by the continual abstraction of portions of air which constantly enter the tube from the receiver. The air and mercury escape from the lower flask into a basin, where the mercury is collected and poured back into the funnel, to be repassed through the tube until the exhaustion is complete. As this point is reached, the inclosed air between the mercury cylinders diminishes until the lower part of the tube forms a continuous column of mercury about 30 inches high. The Sprengel pump is Grove's pump under an improved form, and the degree of exhaustion which can be effected by it is a very near approach to *vacuo*. The apparatus has been employed with great success in experiments in which a very perfect exhaustion is required, as in the preparation of incandescent electric lamps and the preparation of Geissler's tubes. In some experiments with the Sprengel pump, Crookes obtained by chemical means a vacuum of $\frac{1}{13000}$ of a millimetre. In these highly rarefied media the pressure is so small that it is very difficult to measure minute differences. M'Leod has devised a very valuable gauge for such purposes, the principle of which is to condense a measured volume of the highly rarefied gas to a much smaller



Sprengel Pump.

NATURAL PHILOSOPHY.

PNEUMATICS.

Fig. 1. Hawkesbee's Air Pump.

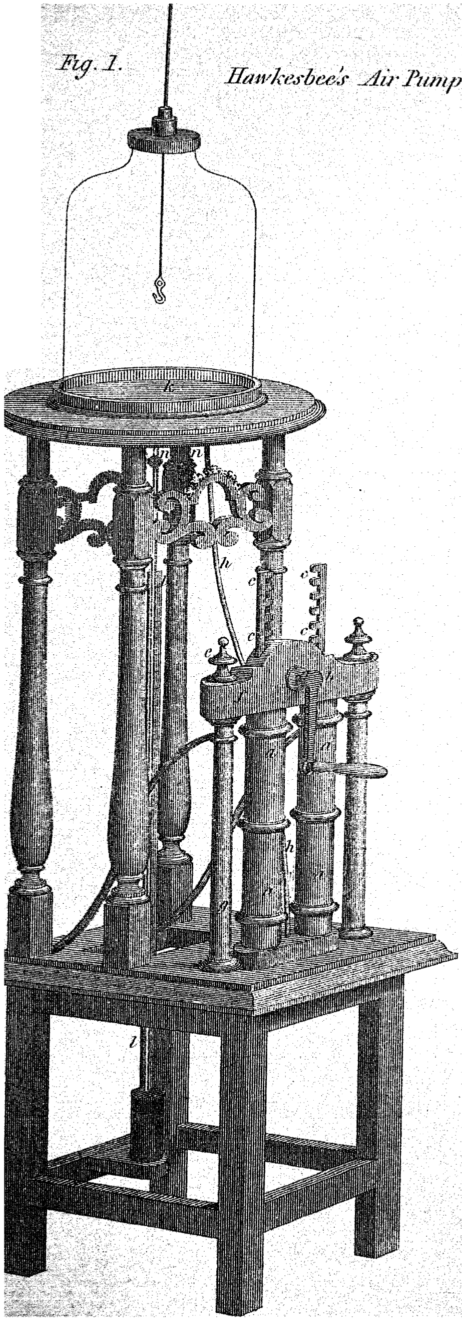
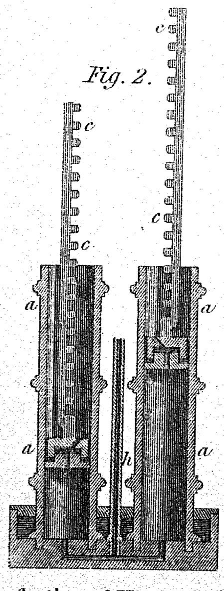


Fig. 2.



Section of Hawkesbee's Air-Pump.

Section of Smeaton's Air-Pump.

Fig. 4.

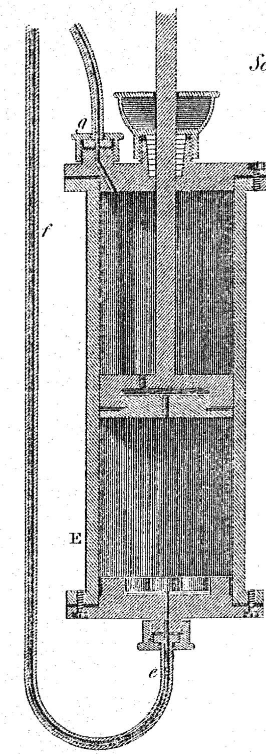
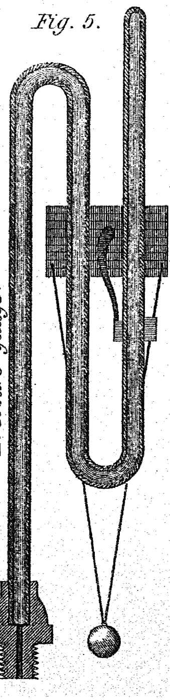


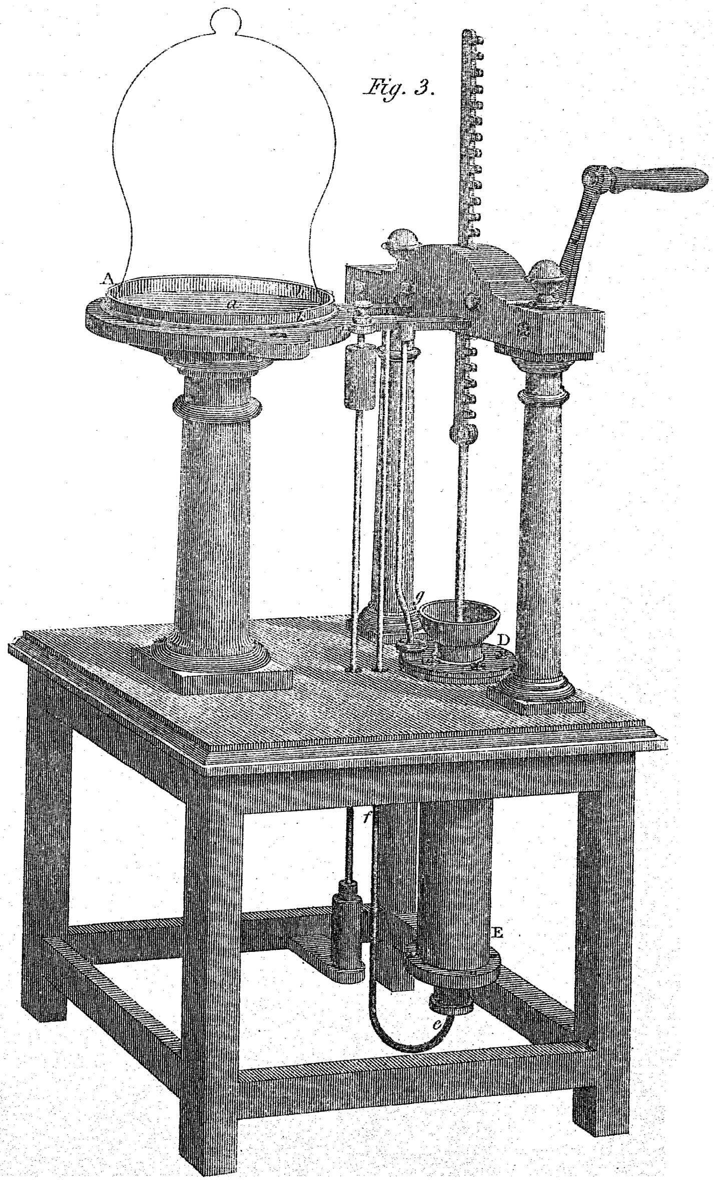
Fig. 5.



Pressure gauge.

Smeaton's Air-Pump.

Fig. 3.

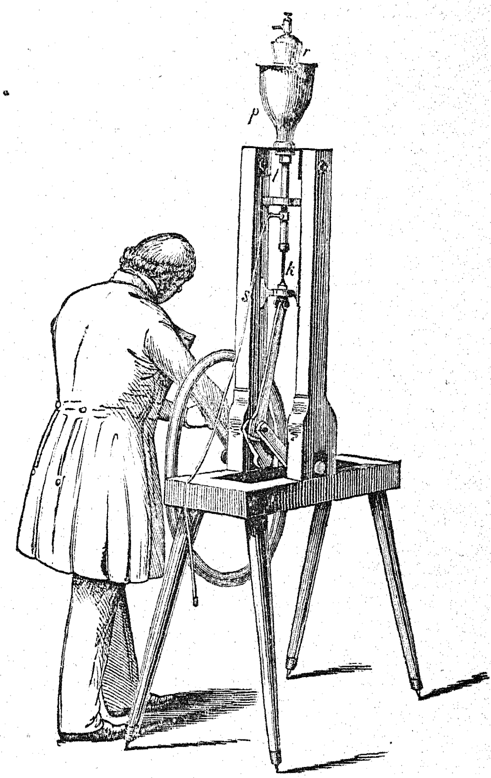


volume, and then to measure its pressure under the new conditions. The most perfect vacua are obtained by absorbing the residual gas, after the exhaustion has proceeded as far as possible, either mechanically or by some substance with which it combines chemically.

The pressure of the air in the receiver of an air-pump, after any number of strokes, is indicated by a gauge, which is generally attached to the connecting pipe of the air-pump. In its simplest form it consists of a straight tube *l l*, fig. 1, Plate XII., open at both ends; the upper end is connected with the receiver, and the lower end dips into a cup of mercury. As the air is removed from the receiver the pressure inside the tube is less than that on the mercury in the cup, and the mercury rises in the tube. If the barometer at the time stands at 30 inches, and the mercury has risen 4 inches in the tube, the pressure of the air in the receiver is $30 - 4 = 26$ inches. The length of this form of gauge renders it somewhat inconvenient. The gauge usually employed consists of a bent tube (fig. 5) having one end closed and the other open. Each branch is about 10 inches in length, and the closed end is filled with mercury, the weight of which is supported by atmospheric pressure. The open end of the tube communicates with the receiver of the air-pump. The first few strokes of the pump do not produce any change in the gauge, but as soon as the tension of the air in the receiver is less than the pressure due to the column of mercury in the closed end of the tube, the mercury begins to fall, and the difference of level of the mercury in the two ends measures the pressure of the air in the receiver.

The employment of vacua and atmospheric pressure in long tubes is largely utilized for the transmission of telegraph messages between station and station and the central offices in cities and large towns. In Paris, London, Manchester, Glasgow, and other places, the *pneumatic despatch tubes* are in constant use. They consist of leaden pipes about 3 inches in diameter, perfectly smooth, and uniform inside from end to end, inclosed in iron piping laid down in the streets, and brought up into the various local stations, where the tube may be opened or closed for the despatch or delivery of a message, by a special arrangement of air-tight valves and shutters. Continuous vacuum pressure is maintained throughout the length of the tube by a pumping engine exhausting the air from the end of the tube in the central station. The paper messages to be sent along the tube are folded up and placed inside a small cylindrical plug or carrier, which exactly fits the tube, and which on being placed in the valve arrangement at the local station enters the main tube and is at once shot or sucked forward with great velocity by the pressure of the air into the receiving chamber at the central telegraph station, from whence they are transmitted on to their destination. The employment of the pneumatic despatch enables a vast amount of local telegraphic business to be carried on entirely by mechanical means. The pneumatic railway laid down by Samuda in 1847, between Exeter and Teignmouth, on the South Devon coast, was also upon the principle of vacuum pressure propelling forward a piston in a tube. The carriages were attached to the piston by an arm passing through a longitudinal flexible slit valve on the top of the tube, kept closed by external atmospheric pressure, and which opened as the arm of the piston traversed the tube, and was again luted down by a heavy roller attached to the carriage as it passed along. The velocity attained sometimes reached 80 miles an hour, but as frequently, owing to leakage along the continuous valve, the speed declined to little more than a walking pace. Ultimately the principle was abandoned as unsuited for the exigencies of railway transit. To maintain the vacuum in the tube, powerful air-pumping engines were erected at each station, which were severally set going by signal to exhaust the next section of tube in advance of the approaching train.

The condensing syringe (figs. 1 and 1*a*, Plate XIII.) consists of a cylinder A B, opening into the air at F, and having two valves, one on the piston *g*, opening towards B, and another *f*, at the bottom of the cylinder. As the piston moves from A to B the valve *g* closes, while the air in *g* B is forced through the valve *f* into a receiver E, tightly screwed upon the bottom of the syringe. On the return stroke *f* closes and *g* opens, and the space B F again becomes filled with a supply of air, which is ready in its turn to be forced through *f* into the receiver. If the machine works perfectly, the same quantity of air will enter the receiver at each stroke of the piston if it is moved through the whole length of the barrel A B.



Apparatus for the Liquefaction of Gases.
k l, condensing syringe; *r*, reservoir of condensed gas; *p*, vessel containing refrigerating material; *s*, pipe supplying the gas.

It has been used in conjunction with intense cold in the liquefaction of gases.

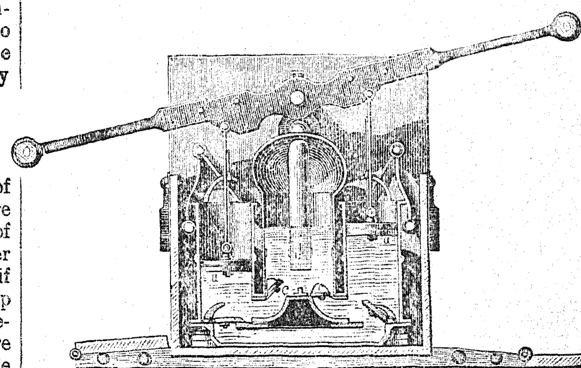
The supply of compressed air to blast furnaces demands a special form of condensing pump which is analogous to the pump for forcing water, and is a double-acting condensing syringe on a large scale. There are no valves in the piston, but there are four valves in the cylinder, two placed top and bottom, opening inwards for the admission of air, and two on the side, opening outwards for its exit. An external pipe or chamber inclosing the two valves for the exit of the air leads to a receiver in which the compressed air is stored up; when the piston descends the top valve and lower side valve will open, and the bottom valve and upper side valve will be closed by atmospheric pressure, while on the ascent of the piston the reverse takes place. A quantity of air is thus forced into the pipe leading to the receiver at each up and down stroke of the piston.

Another important application of compressed air is the smith's bellows. The ordinary bellows has an intermittent action, but the forge bellows has a continuous discharge of air. This is effected by a double chamber, the lower one corresponding to an ordinary bellows, and having a valve in the upper board opening upwards into the upper chamber. When the lower board falls the lower valve opens, and the chamber becomes filled with air. Upon raising the lower board the valve closes, and the contained air is forced through the valve in the middle board into the upper chamber, from whence it escapes by a pipe in a blast. A weight on the upper board keeps the air in the upper chamber under a pressure which may be adjusted, and the escape pipe is contracted at the nozzle, so that the air flows out less rapidly than it is pumped in. By this means the supply is continuous.

Compressed air is likewise employed to sound the powerful

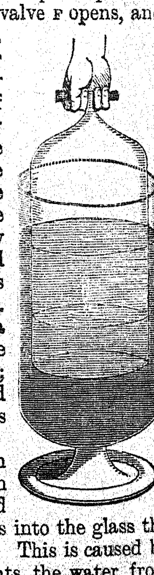
fog syrens, fixed at various stations around the coast, and is also made use of in the Holmes' mechanical fog-horn. The condenser in this latter apparatus consists of two cylinders, the one working in the other to form a hollow piston. The external cylinder is closed at the bottom by the trumpet-mouth of the horn, which has its conical tube and reed carried up through the centre of the cylinder to nearly reach the top; the upper end of this cylinder is open. The internal cylinder, which takes the place of the piston, is open at the bottom and closed at the top, so that it is free to work up and down within the external tube over the interior tube of the trumpet. A handle attached to the upper plate of this cylinder enables it to be drawn out and again forcibly depressed. On drawing the piston cylinder out a certain length air passes in through the reed of the trumpet and fills the chamber. On depressing the cylinder the air is compressed, and issuing through the reed causes the trumpet to emit a very powerful blast, which is continuous so long as the cylinder is descending. These fog-horns are largely used by vessels of the mercantile marine at home and abroad.

The common or suction pump was invented about 200 years before the Christian era. Its action was not, however, understood until after the invention of the barometer tube for measuring atmospheric pressure. If air be sucked out of a tube dipping into water, the pressure of the atmosphere will force the water up the tube, and will sustain a column of about 32 feet in height. The weight of this column of water therefore equals the atmospheric pressure without; and if some of the water be removed more liquid will be forced up to supply its place. The action of the suction pump is therefore dependent upon atmospheric pressure. Pumps are divided into three classes—the *suction* or *lift-pump*, the *force-pump*, and the *suction and forcing pump*. The *suction-pump* consists of a cylinder fitted with a piston and valve, and connected by a second valve with a pipe, the end of which is pierced with a number of small holes, and placed under the surface of the water in the well or reservoir, the liquid in which it is required to raise. A common suction pump is shown fig. 2, Plate XIII. in section. A B C D is the barrel, Z the piston working in the barrel, F the piston valve opening upwards, E the pipe valve, also opening upwards into the barrel. The suction pipe dipping into the well is attached at A C, the perforated end of which is below the surface, M N, of the water to be raised. The action of the pump is as follows:—When the valve F is at the bottom of the barrel the whole cylinder will be full of air, and the level of the water M N will be the same inside and outside the suction tube. If the piston Z be now raised to K I, the valve F will close and the valve E will open, because the pressure of the air in the suction pipe is much greater than that in A K I C, the portion of the barrel under the valve F. Hence the water rises to some point, *x u*, in the suction pipe above the level, M N, of the reservoir. On the descent of the piston Z the valve F opens and E closes, so that the air in the barrel escapes through F, the column of water in the suction pipe remaining stationary at *x u*. On the next ascent of the piston the same action takes place, and more air being withdrawn the water rises to a higher level, *y z*, in the suction pipe, until finally the water rises through the valve E. It is then compelled to pass through the valve F, and is *lifted* by the piston till it flows out of the spout O at the top of the barrel. The length of the suction-pipe in this kind of pump is restricted to 28 or 29 feet between the level M N of the water in the reservoir and the valve E. Practically beyond this distance atmospheric pressure will not lift the water, as the vacuum produced in the barrel is not perfect, owing to the piston not fitting accurately on the sides of the barrel. When the water has passed the piston the height to which it can be brought depends upon the power which gives motion to the piston. The action of the *force-pump* (fig. 3, Plate XIII.) depends both on exhaustion and pressure, and the piston has no valve. The action is the same as the suction-pump, until the water enters the barrel G H. Then as the piston P is raised, the water occupies the space beneath it, and passing through the valve F rises in the pipe R V to the same level as in the barrel. As the piston descends the valve E is closed, and all the water contained in the barrel is *forced* up the pipe and prevented from returning by the valve F. In this way water can be forced up to any height consistent with the strength of the pump and valves, or can be made to rise in a jet from the upper end of the pipe. No flow of water from the pipe R V, however, takes place during the ascent of the piston in the barrel. In order to produce a *continuous* stream through the pipe at V the end of the pipe Q R is introduced into an air-tight chamber, into which the valve F opens. When the water has been forced into this chamber till it rises above the lower end, Q R, of the pipe, the air which is contained in the chamber between the surface of the water and the top of the chamber, is suddenly compressed at each stroke of the piston, and by its reaction on the water forces it through the pipe R V in a continuous stream. This principle is applied in the construction of the fire-engine, which consists of a double



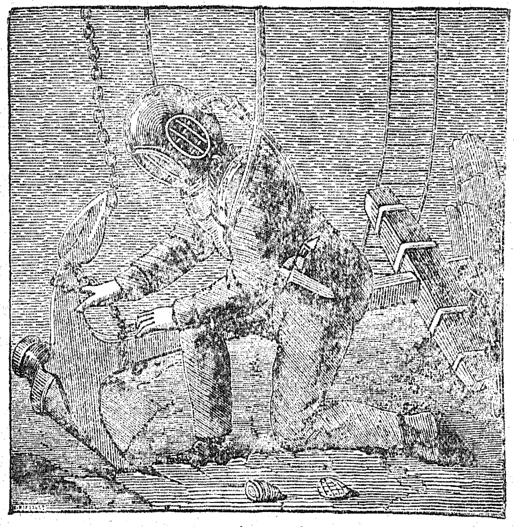
Double Forcing-pump.

forcing-pump, *a a*, connected with an air-chamber, *e*. The constancy of the jet of water thrown up is obtained not only by the reaction of pressure in the air-chamber, but also by the alternate action of the two force-pumps. The two pistons are worked by a lever, so that one ascends while the other descends. Every time the pistons momentarily stop, the flow is maintained by the elasticity of the air in the air-chamber. The *lifting-pump* is a modification of the common pump, in which the water discharged from the pump barrel, which is closed at the top, enters a pipe furnished with a valve, and communicates with the spout at any required elevation. Fig. 4 is a section of an ordinary form of lifting-pump. The barrel B D is inverted, in which a piston works up and down by the connecting rods, Y X, attached to the guide rod, T Z, where the power is applied. The valve F opens upwards. When the piston ascends lifting water the valve F opens, and the water is discharged into the pipe V. When the piston descends the valve at F closes, and prevents the return of the water in the pipe into the barrel. Each stroke of the piston increases the quantity of water in the pipe V, and thus the water may be raised to any height, provided that the barrel and pipe and the piston rod be strong enough to bear the pressure of the superincumbent column of water. Very powerful steam lifting pumps are employed for mining purposes, to keep coal-pits emptied of their rapidly collecting waters. A rod, fixed to the end of the beam of a steam-engine, rises and falls in accordance with its upward and downward motion; the mouth of the shaft is preserved entirely free and open, and the pump-rods are also kept clear of any obstruction.

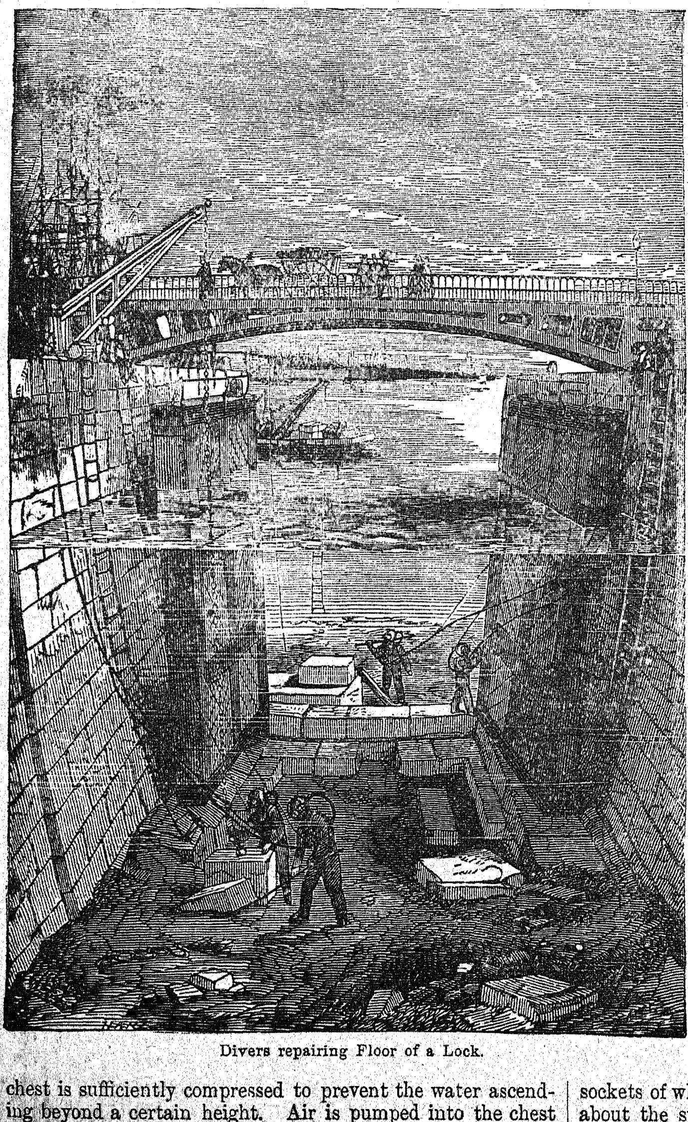


When a glass tumbler is inverted with its mouth horizontal, and is pressed down into a basin of water, it will be found that though some portion of water ascends into the glass the greater part of the glass is without water. This is caused by the compression of the air, which prevents the water from rising in the glass. The *diving bell* works on the same principle. A heavy iron chest, open at the bottom, is sus-

pended from a chain and lowered into the water with its open end downwards. The water will then rise till the air in the



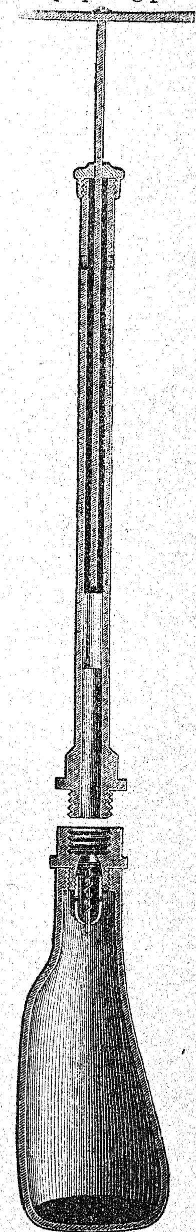
[illegible] Diving Dress.



Divers repairing Floor of a Lock.

chest is sufficiently compressed to prevent the water ascending beyond a certain height. Air is pumped into the chest through a pipe communicating with an air-pump at the surface, and the impure air is allowed to escape through another pipe. The *diving dress and helmet* are only another application of the same principle. It is largely employed in all submarine engineering operations, such as the construction of piers for bridges, the laying of the foundations for breakwaters and jetties, the raising of sunken vessels, the blasting of rocks under water, &c.

The force of highly compressed air is made use of in the *air-gun* for projecting bullets, in which the propelling power is the rush of condensed air allowed to escape from a chamber, instead of the formation of gases arising from the ignition of gunpowder. Fig. 5, Plate XIII., is a form of air-gun in which the compressed air is contained in a chamber in the gun-stock. The mechanism by which the trigger liberates a portion of the condensed air for the propulsion of the bullet is seen in the section, and the mode in which the air is condensed in the detachable stock by means of a syringe in the annexed cut.

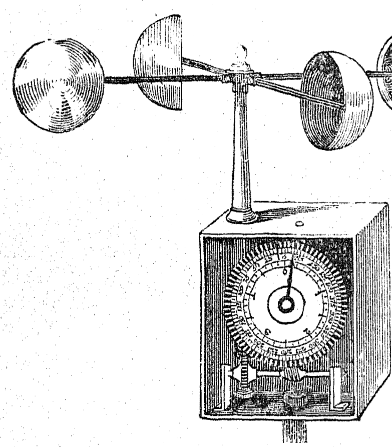


Condensing Syringe and Stock of Air-gun.

The *anemomter* is an instrument for registering the velocity and pressure of currents of air in the atmosphere. This is generally effected by observing the mechanical effect which is produced on the apparatus. The anemometer was originally invented by Wolf in 1746. The instrument, as constructed by him, consisted of four small sails, like those of a windmill, which turned on a horizontal axis. This axis was connected by wheelwork with another bar, carrying a pointer and kept in the vertical position by a weight at the lower end. The wind acting on the sails caused this pointer to turn in a vertical plane, and when in such a position that the weight on its counter balanced the pressure of the air current on the sails, the angle which it made with the vertical line passed through the axis indicated a measure of the wind's force.

Lind's anemometer (fig. 6 of Plate), consists of two glass tubes, A B, C D, about 9 inches long and one-quarter inch diameter, connected together at the bottom by a small bent glass tube, *a b*, one-tenth of an inch in diameter, to check the undulations of the water in the tubes, caused by any sudden pressure of wind. On the upper end of the tube, A B, is fitted a thin metal tube, having its mouth, F, open in a horizontal direction to receive the wind. The two branches of the tube are connected to a steel spindle, K L, by brass arms, the sliding sockets of which, *e* and *f*, enable the instrument to turn easily about the spindle, which is fixed into a block by a screw at

its lower end. When the instrument is used water is poured in at F till the tubes are half full; then by exposing it to the wind, the air blowing in at the mouth, F, forces the water lower down in the tube, A B, and raises it correspondingly higher in the tube, C D; and the difference between the heights of the surfaces of the water in the two tubes, as indicated by the scale H I, will be the height of a column of water whose pressure is equal to the force or momentum of the wind striking against an equal base. A cubic foot of water weighs 1000 ounces or $62\frac{1}{2}$ lbs., the twelfth part of which is about $5\frac{1}{5}$ lbs.; therefore, for every inch the surface of the water is raised the force of the wind will be equal to the same number of $5\frac{1}{5}$ lbs. on a square foot. Thus, if the water stands 3 inches higher in one tube than in the other, the force or pressure of the wind will be equal to $15\frac{3}{5}$ lbs. on the surface of a square foot. Leslie found by experiment that the cooling power of air is proportional to its velocity, and determined that velocity from the formula $V = 1 - \frac{9T}{2t}$ by means of a spirit thermometer. V is the velocity of the wind in miles per hour; T the time in which the spirit in the tube descends through half the number of degrees to which, by the application of heat, it has been raised above the degree at which it previously stood; and t the time in which the spirit, when exposed to the action of the wind and raised as before, descends through an equal number of degrees. Cassella's anemometer is an improvement upon Robinson's, and is the most reliable form in use. It consists of four hemispherical cups mounted



Cassella's Anemometer.

upon four arms revolving on a spindle. When their diametrical planes are exposed to a current of air they revolve with *one-third the wind's velocity*. A simple arrangement of wheels and screws in connection with the axis indicates, by means of two indices, the space traversed by the wind. The stationary index at the top of the dial registers the number of miles—*under* 5—and furlongs which the wind may have travelled, in addition to the number of miles shown by the traversing index, which revolves with the dial and indicates the transit of every 5 miles. The graduation is to 500. By folding the arms this anemometer is rendered portable. The mean velocity of the wind in this climate is from 18 to 20 feet a second. With a less velocity no movement is perceptible, and smoke ascends straight; a velocity of 56 to 100 feet is a storm, and from 90 to 120 a hurricane.

In considering the subject of hydrodynamics, whether with reference to liquids or expansible gases, it will be observed that the motion of fluids is infinitely more complicated than that of their equilibrium. When their motions are slow it is reasonable to suppose that the law of the equable distribution of pressure takes place; but in every rapid displacement of their parts, one among the other, it is more difficult to conceive how such an equable distribution can be accomplished. Independent of this, there are difficulties of an almost insuperable nature to the regular deductive applications of the general principles of mechanics to this subject, arising from the excessive intricacy of the pure mathematical inquiries which its investigation demands.

Sir Isaac Newton was the first who attempted to deduce any conclusions respecting the motion of fluid masses by direct reasoning from dynamical principles, and thus laid the foundation of hydrodynamics; but it was not until the time of D'Alembert that the method of reducing any question respecting the motion of fluids and gases, under the action of forces, to strict mathematical investigation could be said to be completely understood. But the cases in which this mode of treating such questions can be satisfactorily applied are few as compared with those in which the experimental method of inquiry is not preferable.

For instance, a knowledge of the resistance of fluids to bodies moving through them is of great importance in naval architecture and in gunnery, where the resistance of the air acts to an enormous extent upon the surfaces of the bodies passing through them. Again, the same applies to the practical subjects which depend mainly on this branch of science, as the use of sails in navigation, the construction of windmills and water-wheels, the transmission of water through main-pipes and channels, the construction of docks and harbours, and many other equally important practical applications of the science of hydrodynamics.

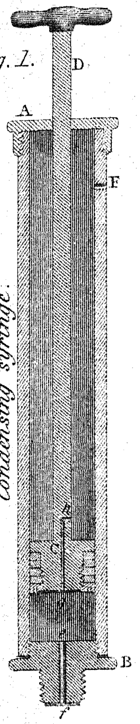
LOGIC.—CHAPTER VI.

IDEATION AND EXPRESSION—JUDGMENT—INTELLECTUAL SURVEY OF PROPOSITIONS—SYLLOGISM—SYLLOGISTIC FIGURES.

To distinguish the abstract from the concrete is not nearly so difficult as to perceive the abstract in or through the concrete. We see three objects—*e.g.* green grass, a green dress, a green paling—and we find it quite easy to conceive of the abstract "greenness," which they all suggest, without confusion of the real things, characterized by that colour, with that colour itself. Nor, in fact, do we feel it to be a severe mental task to accept of substantive existences as realities, capable of possessing variable adjectival qualities; for example, a cow—which may be red, brown, white, or particoloured; large, small, or medium in size; finely-developed or ugly in form; of great or little value. But if we try to discover in the objects which are brought before us some abstract notion which shall be applicable to them all, however diverse, the intellectual effort is considerably greater. For example, a fishing-rod, a river, the hedgerow which margins it, the journey made to reach that river, the desire which prompted the taking of that particular journey, the illness which preceded and perhaps awakened the desire, and the absence which had intervened between one's having wielded a fishing-rod in the reaches of that river in youth and his plying the angler's craft in its waters now, may each and all be suggestive of length, and "the long" is an abstract form of ideation which each may excite—because it can be perceived in each. Suppose, again, that we have been interested by a building, a statue, a landscape, a poem descriptive of either or all, a reflection in that poem suggestive of some specific thought of singular appropriateness and attractiveness, and we seek to see through all these the one pervading influence which charms in all, and call it beauty, we have exercised a higher and more subtle power of intellectual conception. The mental phenomena which have occurred within us have passed from the pictorialism of sense to the conceptualism of philosophical imagination. We see an act performed, and it suggests the kindness and promptitude of the person by whom it is done. A further reach of thought shows us the sympathy in which the act originated. We feel a specific uneasy soreness, and we complain of a pain; but when the physician asks what sort of pain is being experienced, he has in his mind an abstract yet defined meaning attached to the word pain, and has arranged under it the several sub-classes from which it is generalized. He wishes to see, through the concrete pain, the abstract class to which, in the system of medicine he has studied, it belongs, and with which, when

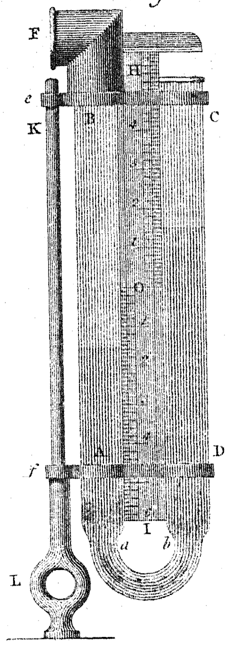
PNEUMATICS.

Fig. 1.



Condensing syringe.

Fig. 6.



Lind's Anemometer.

Fig. 2.

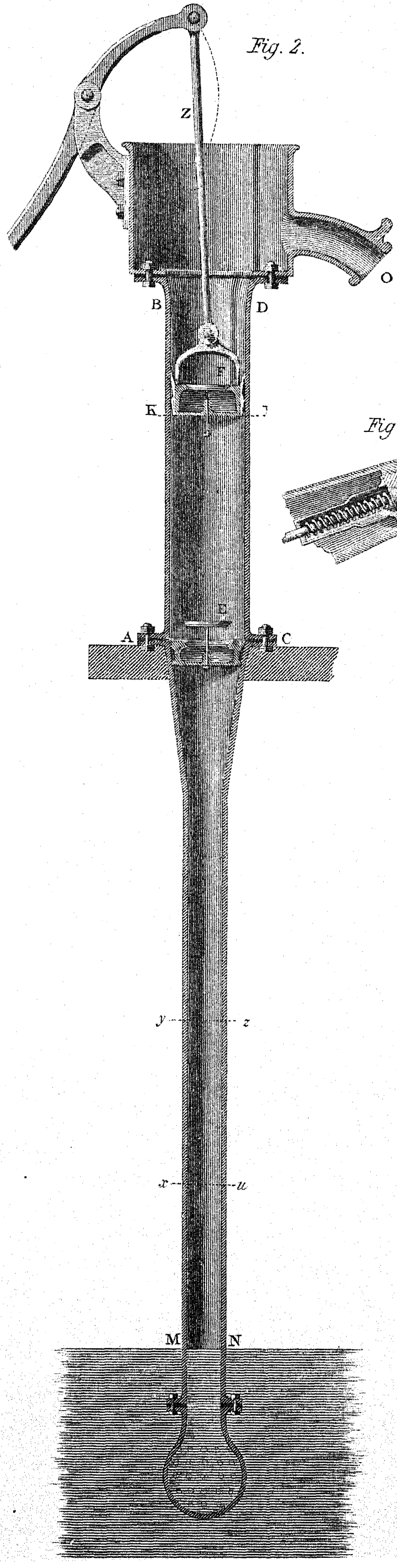


Fig. 1a

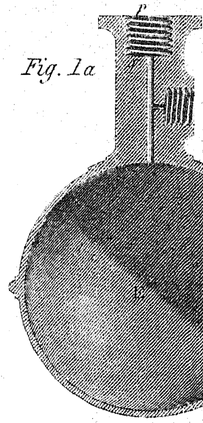
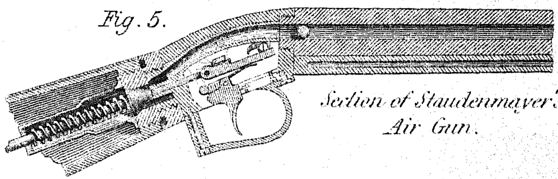


Fig. 5.



Section of Staudenmayer's, Air Gun.

Fig. 3.

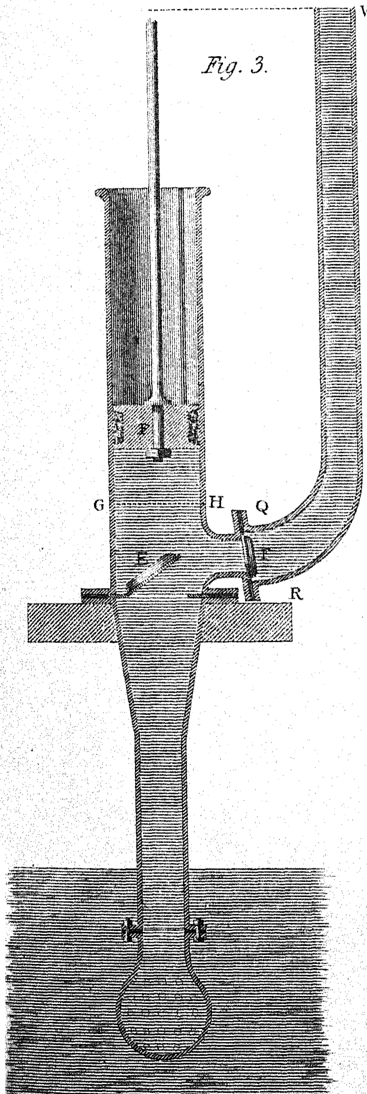
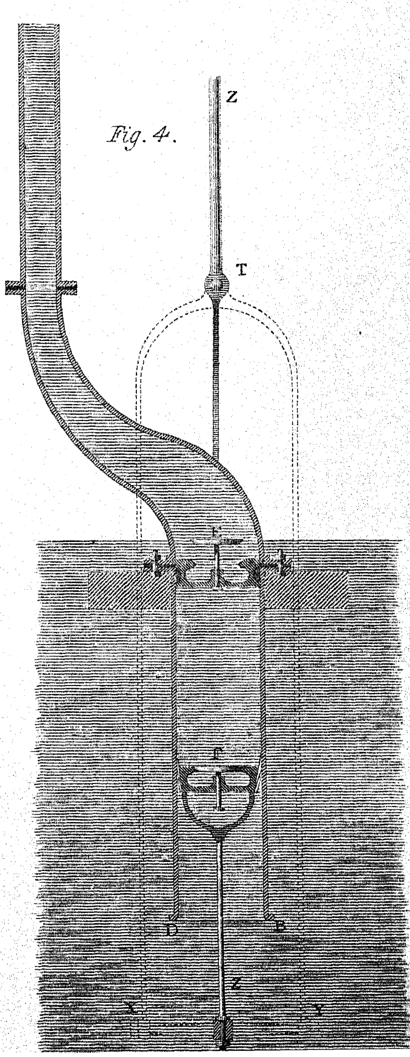


Fig. 4.



found, he has learned more or less effectively to deal. Abstract truth is the result of continuous and coherent investigative research, exercised not only on a succession of objects similar in some one point of view, but also, as a general rule, by a succession of minds co-operating in the same line of inquiry. Every science begins with facts and ends with truths. These truths are really found in the facts, are discovered through the facts, and yet they are, as an abstract body of scientific statements, quite distinct from the concrete facts by an examination of which they have been obtained. The outward world is interpreted and illuminated by the truths which science has seen and disclosed.

All statements of fact or truth take the form of propositions. "I saw a black cat" is a proposition as to an individual isolated fact. "All the Saxon lawgivers showed great wisdom in the business of legislation" is a proposition laid down in Crabb's "History of English Law" as a historical generalization drawn from the observations made regarding a long course of procedure and careful study of an extensive series of enactments. "All history proves man to be a fallen creature" is a proposition founded (or professing to be so) on an induction made from all human records of facts, conditions, events, and transactions. "All change is preceded by a cause" is a proposition in which the philosophic mind expresses the result of its experiences in all circumstances. It expresses itself variously according to the view of things being taken by the mind and the particular topic engaging its attention at the time. It forms, for instance, the inner core of the affirmative statement made by Newton in his first law of motion:—"All bodies continue in their [original or originally observed] state of (1) rest, or (2) of uniform motion in a straight line—except in so far as it [is or] may be compelled, by impressed forces, to change that [original] state." Precisely the same proposition or law may be stated in a negative form:—"No body can alter its [original or originally observed] state of (1) rest, or (2) uniform motion in a straight line—except in so far as," &c. This statement of the law of inertia requires to be adapted in its form of expression to the purpose of the mind in uttering it. In inculcating a truth and advancing it as a thing to be believed in and accepted, a proposition naturally takes the affirmative form; in resisting an opinion previously entertained, in seeking to displace a prevailing (or generally believed and received) opinion, or in advancing an opinion in opposition to one either really accepted or supposedly held, a proposition as naturally takes the negative form. "A asserts and E denies universally" is the explanation of the logical shorthand mnemonic in regard to the universal affirmatives and negatives which are engrossed in propositions, and it is of great importance to acquire at once the clearness of perception and the dexterity of expression which shall enable us with promptitude and correctness to employ and apply either as is most suitable to the purpose in hand, which is, in logic, the acquisition or conveyance of reasoned truth and the production of its intended result—conviction. If, in a universal proposition, the relation be that of identity of subject and predicate, the proposition may be at once converted, and may indifferently, so far as its power and value are concerned, be expressed as A or E. But if we wish to exhibit, with mistakeless precision, the form of thought, we must see (1) that all that is in our thought should be not implicitly only, but explicitly, brought into view, and (2) that whatever is not involved in our thought should be distinctly and imperatively discharged from the expressions employed. For instance, if we say "Man is an animal," our proposition would mean, All the individuals of the race of man have the qualities belonging to the class of creatures denominated animals, *i.e.* "All man is some animal;" and this would convert into "Some animal is all man," implying that some of those creatures denominated animals include those which we class as man, *i.e.* I = particular affirmative, and might be converted into O, "Some animal is not man." To manage the proposition as an instrument in reasoning we require to understand precisely the original equivalence of subject and predicate which it asserts, and the mode in which exactly the same amount of material affirmation may be included in and expressed by the transpositions necessary to be made to change from one quantity and quality to another. It is indeed one of the most requisite elements in what Ralph Lever, dean of Durham, calls "the art of witcraft," that we should be able to retain and maintain the absolute significance of thought amidst all the possible contingencies of expression, in order that we may secure the observance of the laws of formal thought notwithstanding the accidental arrangements which the necessities of language may impose on us.

The great point, therefore, is to acquire and possess that certainty which is the result of clear vision. When a whole subject is distinctly understood in all its parts and features, viewed in connection one with another, and carefully compared with each other, the propositions in which the knowledge thus attained is expressed should be explicit and distinct, and the mind ought to be able to see and know the exact relations of quality and quantity which part bears to part. If the intellectual perception be carefully trained, the propositions to which it assents are likely to be accurate in substance and capable of being made clear in expression. When our ideas are made the subject of impartial intellectual comparison, their points of agreement and of difference can be distinctly seen and correctly estimated. Their joint and co-operating terms can be tested by reference to experience, and the equal, steady, and powerful light of the well-trained mind acquires a nicety and precision of balancing power which men recognize as excellence of judgment. This possession of the power of viewing the concrete facts of nature and of life, realizing them in the intellect as truths, and expressing them in language as propositions clearly expressed and easily understood, is of high value; and it is one of the aims of logic to train men's minds to such an examination of its own operations and criticism of their results as shall regulate the practice of the intellect when engaged in thought.

This comparison between idea and expression brings into notice the difference between those relations which are slight and variable and those which are important and permanent. The former are collected together as conversational topics and history, and the latter as science. The relations of contemporaneousness and succession in time and of immediateness or remoteness of incidence or concurrence are seen to be quite different from those of similarity or dissimilarity, equality or inequality, and generally of equivalence and ratio, which manifest themselves not only in affairs of daily occurrence, but also in the more recondite and peculiar concerns on which science exercises its investigations. But higher even than these are the relations of mutual dependence and causation, of antecedence, correlation, and succession, of order and arrangement, which characterize, show themselves in, and are implied by the qualities, tendencies, operations, connections, and influences of things, all of which are expressed in propositions, and constitute, as the case may be, facts, opinions, or truths. The mind, however, can neither remember, reflect upon, nor deduce any important truths from experiences isolated, objects unclassified, or statements made in incoherent individuality. It is impelled to submit all its acquisitions of sensation, ideation, imagination, and emotion to an explicit intellectual survey. The infinite multiplicity of facts, impressions, experiences, ideas, opinions, and inferences which have their place in our thoughts, have a very extensive range. They cannot be retained in their original separate and distinct form. It is a necessity of nature and of mind that these should be gathered and classed; that some plan, order, and arrangement should, if possible, be introduced among them; that some system should be impressed on all that comes within the sphere and region of reflective thought. Opposite and contradictory propositions (either real or seeming) require to be compared; imperfectly realized ideas must be searched into and furnished with more adequate forms of statement; slight and impalpable differences of signification or expression suggest their discardment; and a general desire for determining the consistency of those different propositions which have pressed themselves on the mind for storage and registration, and demanded acceptance and belief, induces the intellect to devise some means by which the fallacious and mistaken may be distinguished from the indisputable and the true. This endeavour to appraise the value, determine the

weight, measure the extent, and ascertain the degree of certainty which belongs to the judgments presented to us in propositions, induces the intellect to re-survey comparatively, and in detail, all the propositions which refer to similar matters, and which require to be taken into its calculations (Gr. *logizomai*). For this purpose it brings them together, places them side by side, and is thus able to deduce (Gr. *sullogizomai*) from their correlations some formal estimate of their conformity or nonconformity with one another. This process is called syllogizing, and the faculty by which it is performed is known as reasoning—*i.e.* the exercise of power of inference for the deductive discovery of truth.

The syllogism is a special systematic form of arranging a series of propositions in such a distinct method of juxtaposition that the relative consistency or inconsistency of any two statements so set down may be observed clearly and at once. The degree of relation or irrelation, congruity or incongruity, between two propositions considered apart may not strike the mind, and their latent discordancy may be unobserved—especially if the terms in which they are expressed are varied. But when they are placed precisely under the view of the intellect, and the mind is called upon to examine and compare them carefully (having their forms of expression made as similar as may be), the latent likeness or unlikeness generally becomes patent and palpable. The art of syllogizing does not consist in putting any two syllogisms together, and drawing from them any conclusion which they will yield. The arrangement and combination of the propositions [to be] brought side by side and compared; the decision of the form and figure of the syllogism which may be most advisably and advantageously made use of for the purpose on hand, constitute the chief merit of the logician. It is a great mistake —very prevalent among critics of logical procedure—to suppose that because it is very easy (so simple that the veriest tyro finds no difficulty in it) to draw a correct conclusion from those given premises which appear in text-books, there is, in reality, no utility in syllogistic reasoning, and no talent required to reduce any process of reasoning to a logically valid form—*i. e.* to a syllogism. The art and mystery of syllogism is so to place the propositions that the result of comparing them together shall be a just and relevant process of reasoning, accurately adapted to the subject of inquiry. Every syllogism is a single process of reasoning consisting of three propositions so arranged that if the two prior propositions—called premises (Lat. *præmitto*, I send forward in advance), because they are set forward as trustworthy statements—are taken for granted or accepted as true, the third proposition—called the conclusion—must also be granted or accepted. There are two facts on which the cogency of the syllogism, in the ultimate resort, depends—viz. (1) when the mind observes that any two notions agree with a third, it finds itself compelled to admit that they agree with each other; (2) when the mind finds that of any two notions one agrees and the other disagrees with any third, it is under the necessity of regarding them as disagreeing with one another. These two facts, logic reduces to a readily applicable principle, which is capable of being employed as a guiding rule to the thinker in each separate step taken in the course of any process of reasoning. Expressed in the most general terms it stands thus—viz. Whatever distinctly perceived or precisely understood relation of subject and predicate subsists between either of two terms and a common third term, with which both are related—either congruently or incongruently—that very same relation subsists between these two terms themselves. This is "the one supreme canon" by which syllogistic reasoning is regulated. The whole doctrine of categorical syllogisms is at once exhaustively and all-sufficiently laid down in it, and every single step in reasoning carried on in accordance with that canon is irrefragably valid. It follows from this, that if each separate act of reasoning, as it is performed, punctiliously observes the syllogistic canon, there cannot be—however lengthy and intricate the process may be—any flaw or error; but any error, however infinitesimal at its introduction, vitiates and invalidates with ever-increasing objectionableness any series of exposition or argumentation. Logic supplies the means of testing the validity of every single link in any chain of thought, and that which seems, from its extreme simplicity, an almost worthless waste of ingenuity, is just on that account the more serviceable and the more indispensable. The certain attainment of great ends by the simplest means is the highest reach of human aspiration and the consummation of possibility in the region of reasoning.

Each simple categorical (Gr. *kategoreo*, I declare), *i.e.* declarative syllogism, consists of three categorical propositions. These three propositions contain three chief notions. The notion which constitutes the subject in the conclusion is called the minor term; that which becomes the predicate in the conclusion is the major notion or term—the two in relation to one another are called the extremes; and the term employed for comparing the one with the other, and as the common element in the inference—the mediator between the two extremes—is called the middle term. The premise which contains the major term is called the major premise, that which contains the minor notion the minor premise, and the third, in which the mediated inference is closed, forms the conclusion.

As the syllogism is the type of the *form* of thought, its variations in arrangement have been called by the logicians syllogistic figures. There are four possible variations in the position which the middle term, *i.e.* the term used as the medium of mutual comparison, can take. It is readily seen that the middle term may be (1) subject in the one premise and predicate in the other, (2) predicate in each premise, or (3) subject in both. But in those middle terms which are included in the first case two subdivisions are possible, for (i.) the middle term may be subject to the major term and predicate to the minor, and (ii.) predicate to the major and subject to the minor term. The former of these sections constitutes now the [technical] *first* figure, and the latter the *fourth*. Aristotle recognized only three figures; Galen critically introduced the fourth. These figures may be presented to the eye in the following tabular scheme, in which S signifies subject, P predicate, and (M) middle term:—

1.	2.	3.	4.
(M) *P*.	*P* (M).	(M) *P*.	*P* (M).
S (M).	*S* (M).	(M) *S*.	(M) *S*.
S P.	S P.	S P.	S P.

An examination of the scheme will show that in all cases the middle term vanishes when its mediating umpireship has been accomplished, and that in fig. 1 the middle term is subject in the major and predicate in the minor premise; in fig. 2 the middle term is the predicate in each premise; in fig. 3 the middle term is the subject in both premises; and in fig. 4 the middle term is predicate in the major and subject in the minor premise.

These may now be exemplified in concrete specimens, and for this purpose we select the following simple scholastic instances given in the late Dr. F. Ueberweg's "Logic" [German], translated by T. M. Lindsay:—

I. Every *virtue* is praiseworthy. Eloquence is a *virtue*. Eloquence is praiseworthy.	III. Every virtue is *praiseworthy*. Every virtue is *useful*. Some useful thing is praiseworthy.
II. No vice is *praiseworthy*. Eloquence is *praiseworthy*. Eloquence is not a vice.	IV. Every *virtue* is praiseworthy. Everything praiseworthy is *useful*. Something useful is a virtue.

As these four figures have each four possible forms—in quantity and quality—of combining the premises, and as each form has three terms in its three propositions, there seems to be on merely arithmetical grounds sixty-four possible syllogistic figures, viz. $4 \times 4 \times 4 = 64$. Logic tests all these possible forms, takes cognizance of their validity or invalidity, and by its researches enables us to economize thought and secure the best possible adaptations of syllogistic reasoning to inquiry or argument by showing which are best, most trustworthy, and most suitable for our special purpose.

CHEMISTRY.—CHAPTER IX.

CHLORINE—HYDROCHLORIC ACID—AQUA REGIA—CHLORINE COMPOUNDS—BROMINE—IODINE—FLUORINE—SULPHUR—SULPHUR COMPOUNDS—SULPHURIC ACID—SULPHURETTED HYDROGEN.

THE group of elements, *chlorine, bromine, iodine,* and *fluorine,* which closely resemble each other, possess strongly marked and active properties. On account of the occurrence of chlorine, bromine, and iodine in sea-water, the elements of this group are termed *halogen elements,* and their metallic compounds, *haloid compounds.*

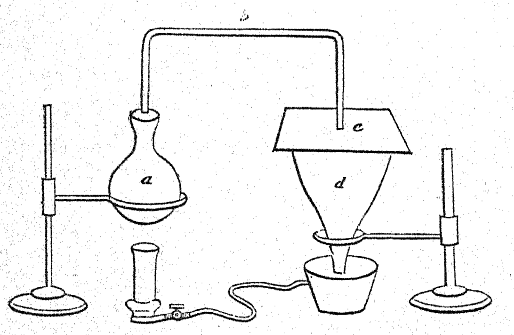
CHLORINE (Cl; atomic weight, 35·37; density, 35·37).—Chlorine was discovered by Scheele in 1774; it does not occur free in nature, but may easily be prepared from its compounds. It is found combined with metals, forming chlorides; of these sodium chloride, or sea or rock salt, is the most common. To obtain chlorine from this salt it must be heated with sulphuric acid and manganese dioxide. Thus—

Sodium Chloride.	Sulphuric Acid.	Manganese dioxide.	Sodium sulphate.	Chlorine.	Manganese sulphate.	Water.

$$2NaCl + 2SO_4H_2 + MnO_2 = Na_2SO_4 + 2Cl + MnSO_4 + H_2O.$$

Chlorine is a green-yellow gas, possessing a most disagreeable and peculiar smell, and when present in large quantities acts as a violent irritant, producing inflammation of the mucous membrane, and even causing death when inhaled. When one part by weight of salt and one part of manganese dioxide are mixed with two parts of sulphuric acid and two of water, and the mixture placed in a flask, *a*, fig. 1, the chlorine gas is given off regularly upon the application of a very slight heat. This gas cannot be collected over water, as it absorbs 2·37 times its bulk of the gas at 15° C., forming the solution termed *chlorine water.* Mercury also enters rapidly into combination with it, forming mercuric chloride or *corrosive sublimate.* It can, however, be easily collected by displacement in a vessel, *d*, with a light cover, *c*, as it is nearly

Fig. 1.



2·5 times as heavy as air. Metals in a finely divided state, when immersed in it, take fire spontaneously. A candle burns in it with a red flame, and a piece of phosphorus introduced into it burns with a pale white light. Copper, tin, zinc, arsenic, and antimony, when introduced into it in thin leaves, or reduced to filings, take fire, and combining with the gas form compounds analogous to the *oxides,* and which are therefore named *chlorides.* Chlorine has the remarkable property of combining with hydrogen to form hydrochloric acid; when these two gases are mixed in equal volumes they combine with explosion on contact with flame, or on exposing the mixture to sunlight. Chlorine will decompose water in the sunlight, combining with the hydrogen and liberating the oxygen. The bleaching action of chlorine also depends upon its power of combining with the hydrogen of water and liberating the oxygen. Dry chlorine gas does not bleach; a piece of cotton cloth or paper, coloured by a vegetable substance, as madder or indigo, may be exposed to its action for weeks without any change of colour taking place. If a few drops of water are added the colouring matter is at once destroyed and the material bleached. The chlorine at once combines with the hydrogen of the water, and the oxygen at the moment of its liberation, when in the *nascent* state, combines with the colouring matters, forming compounds free of colour.

Ordinary free oxygen has not this power, as the *molecules,* or smallest particles of an element which can exist in the free state, do not consist of individual atoms, but of a group of atoms. The molecule of a *compound body* contains two or more dissimilar atoms, whilst the molecule of an *element* contains similar atoms, and the molecules of all bodies, simple or compound, in the gaseous state occupy the same volume. Therefore, the moment an element is liberated from a compound, the single atoms unite together to form a molecule, and the elementary body makes its appearance in the free state; when, however, substances are present on which the element can act chemically, they are decomposed by the chemical attractions of the liberated atoms, which are more active in that state than when united to form a molecule. Chlorine cannot bleach mineral colours. It is largely used in the bleaching of linen and cotton goods, and in the bleaching of rags and esparto grass for the manufacture of paper. For these purposes it is sometimes employed in the form of gas, and sometimes in that of solution in water, but more often in combination with lime, forming the substance called bleaching powder. It is also a powerful disinfectant and deodorant, its action on organic putrefaction being similar to that on organic colouring matters. Chlorine gas, at a pressure of five atmospheres, at a temperature of 15° C., is condensed to a heavy yellow liquid; it has not been solidified as yet.

Hydrochloric Acid (HCl; atomic weight, 36·37; density, 18·18).—Hydrochloric acid or muriatic acid is the only known compound of chlorine and hydrogen, and is obtained when equal volumes of chlorine and hydrogen are mixed and exposed to diffused daylight; the gases then combine, and form the same volume of hydrochloric acid gas. If the light is strong a violent explosion occurs, owing to the sudden evolution of heat consequent upon the combination. In the gas formed, one molecule of hydrogen and one molecule of chlorine give two molecules of hydrochloric acid. Thus—

$$\left.\begin{matrix}H\\H\end{matrix}\right\} + \left.\begin{matrix}Cl\\Cl\end{matrix}\right\} = \left.\begin{matrix}H\\Cl\end{matrix}\right\} + \left.\begin{matrix}H\\Cl\end{matrix}\right\}$$

Hydrochloric acid is readily prepared by heating in a flask a mixture of common salt and sulphuric acid, diluted with a small quantity of water, giving the following reaction:—

Sodium Chlorate.	Sulphuric Acid	Hydrochloric Acid.	Hydrogen sodium sulphate.

$$NaCl + H_2SO_4 = HCl + HNaSO_4.$$

Hydrochloric acid is a colourless gas, 1·269 times heavier than air; it gives off strong fumes in damp air, combining with the moisture. It is very soluble in water, one volume of water at 15° C. dissolving 454 volumes of the gas; this solution forms the ordinary commercial hydrochloric acid. Under a pressure of forty atmospheres the gas forms a limpid liquid. Vast quantities of muriatic acid are obtained as a by-product in the manufacture of sodium carbonate, though the quantity is now reduced since the Weldon soda process has come into general use. The acid thus produced is very impure, containing arsenic, iron, and sulphuric acid in solution.

Nitro-hydrochloric acid or *aqua regia* is a mixture of nitric and hydrochloric acid. Gold and platinum, and many other metallic substances which do not dissolve in either of the acids, are readily soluble in a mixture of the two, and its solvent action depends upon the fact that it contains free chlorine, liberated by the oxidizing action of nitric acid on the hydrogen of the hydrochloric acid. The metals combine directly with this free chlorine and form soluble chlorides, and the sulphides are decomposed by it. Although chlorine and oxygen do not unite directly, they indirectly form the following compounds:—

Chlorine and oxygen.	Corresponding oxy-acids.	Composition by weight. H. C. O.
Chlorine monoxide (Cl_2O)	Hypochlorous acid ($HClO$)	1+35·5+16
Chlorine trioxide (Cl_2O_3)	Chlorous acid ($HClO_2$)	1+35·5+32
Chlorine tetroxide (Cl_2O_4)		
These oxides, not yet obtained, Cl_2O_5 and Cl_2O_7	Chloric acid ($HClO_3$)	1+35·5+48
	Perchloric acid ($HClO_4$)	1+35·5+64

Chlorine monoxide (Cl_2O; atomic weight, 86·7; density, 43·35) is obtained by the action of chlorine upon mercuric oxide. It is a colourless gas, which may be condensed by a freezing mixture to a red liquid, which is highly explosive, decomposing very suddenly into chlorine and oxygen gases. It is very soluble in water, yielding a yellow solution, which bleaches powerfully and more rapidly than chlorine, as twice as much oxygen is liberated from one molecule as from a molecule of chlorine.

Hypochlorous acid is a colourless liquid, possessing a peculiar smell and powerful bleaching properties. It may be prepared from a solution of a hypochlorite, mixed with dilute nitric acid and distilled, when a solution of hypochlorous acid comes over. Hydrochloric acid decomposes hypochlorous acid with the evolution of chlorine, and sulphuric acid liberates hydrochloric acid from the calcium chloride; hence neither of these acids can be used for the preparation of hypochlorous acid from the hypochlorites; but they are employed in the process of bleaching, for the decomposition of the bleaching powder to liberate the chlorine in the fibre of the cloth. This is carried out by first dipping the goods to be bleached in a solution of bleaching powder, and then passing them through dilute hydrochloric or sulphuric acid, when the chlorine is liberated in the fibre of the cloth. The bleaching effect is therefore only seen after the goods have been *soured* or dipped into the acid.

Chloric Acid ($HClO_3$).—When chlorine is passed into a strong hot solution of potassium hydroxide or carbonate, and the liquid concentrated by evaporation, it yields on cooling flat tabular crystals of a colourless salt, consisting of potassium chlorate. From potassium chlorate chloric acid may be obtained by boiling the salt with a solution of hydrofluosilicic acid, which forms an insoluble potassium compound precipitate, and chloric acid remains in solution. Chloric acid solution may, with care, be concentrated in a vacuum over sulphuric acid to a thick syrup, but decomposes on further evaporation. It acts as a powerful oxidizing agent, and dropped on paper produces ignition, in consequence of the facility with which it parts with its oxygen. The oxide of chlorine corresponding to chloric acid, $\left.\begin{matrix} ClO_2 \\ ClO_2 \end{matrix}\right\} O$, is at present unknown.

Perchloric Acid ($HClO_4$; atomic weight, 100·21).—When potassium chlorate is heated, it first melts and begins to evolve oxygen. At a certain stage, however, the whole mass solidifies; and if the decomposition be stopped at this stage a new salt is found contained in the residue, together with chloride and unaltered chlorate. Thus—

$$\underset{\text{Potassium chlorate.}}{2KClO_3} = \underset{\text{Potassium perchlorate.}}{KClO_4} + \underset{\text{Potassium chloride.}}{KCl} + \underset{\text{Oxygen}}{O_2}.$$

This new salt is termed *potassium perchlorate* ($KClO_4$), from a mixture of one part of the dry perchlorate and four of sulphuric acid.

Perchloric acid is readily prepared by distillation in a retort. A colourless fuming liquid condenses in the receiver, which is perchloric acid. It is one of the most powerful oxidizing agents known. Thrown upon paper or wood it produces instant ignition, and when dropped upon charcoal it decomposes with a loud explosion.

The acids of chlorine, as above shown, form an unbroken series, each member differing from the next by one atom of oxygen.

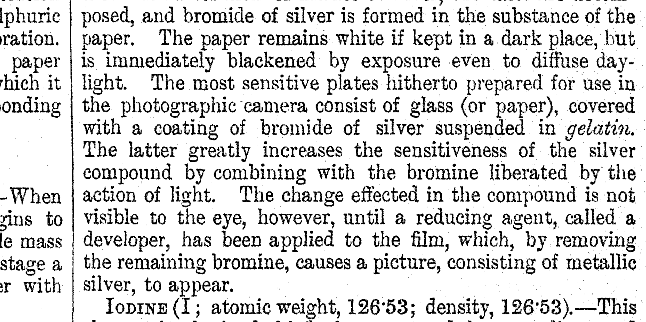
Chlorine combines with nitrogen in an indirect manner to form a very remarkable and dangerous compound, the composition of which has not at present been determined. When chlorine gas is passed into a solution of ammonia, nitrogen is liberated; if an excess of chlorine is employed drops of an oily liquid are seen to form, which explode with fearful violence on being touched. The safest mode of procuring it is to pour a somewhat dilute and tepid solution of pure sal-ammoniac in distilled water into a clean basin, and invert a bottle of chlorine, the neck of which is free from grease, over it. A shallow and heavy leaden cup is placed beneath the mouth of the bottle to collect the product. When enough has been obtained the leaden vessel may be carefully removed with its dangerous contents, the chloride remaining covered with a stratum of liquid. The greatest caution must be used in manipulating even traces of this body, and the operator should protect his face with a strong wire gauze mask. The explosive nature of this compound arises from its constituent elements being very loosely combined and separating with sudden violence.

Bromine (Br; atomic weight, 79·75; density, 79·75).—This element, which nearly resembles chlorine in its properties and compounds, does not occur free in nature, and like chlorine is found combined with sodium and magnesium in the waters of certain mineral springs. It was discovered by Balard in 1826 in the salts obtained by the evaporation of sea-water. To obtain pure bromine, the fact that free chlorine liberates bromine from its combinations with metals, forming a metallic chloride, is made use of. The bromine thus set free may be separated by shaking the liquid up with ether, which dissolves the bromine, forming a bright red solution. At ordinary temperatures bromine is a liquid; at $-22°$ C. it congeals and is very brittle, and it boils at 63° C. It is poisonous. Applied to the skin it colours it deep yellow and corrodes it. It is soluble in water, alcohol, and particularly in ether: with water it forms a crystalline combination at 0° C.; the crystals are octahedrons, of a red tint, and continue permanent, even at the temperature of 10° C. It produces a deep orange yellow colour when mixed even in small quantities with cold solutions of starch. It combines with silver, forming with it an insoluble *bromide*, which, being in contact with organic matter, is quickly blackened by exposure to solar light. On account of this property, bromine is highly valuable in photography. Thus, if a sheet of paper be washed with a very dilute solution of the bromide of potassium, and then with a solution of nitrate of silver, the salts are decomposed, and bromide of silver is formed in the substance of the paper. The paper remains white if kept in a dark place, but is immediately blackened by exposure even to diffuse daylight. The most sensitive plates hitherto prepared for use in the photographic camera consist of glass (or paper), covered with a coating of bromide of silver suspended in *gelatin*. The latter greatly increases the sensitiveness of the silver compound by combining with the bromine liberated by the action of light. The change effected in the compound is not visible to the eye, however, until a reducing agent, called a developer, has been applied to the film, which, by removing the remaining bromine, causes a picture, consisting of metallic silver, to appear.

Iodine (I; atomic weight, 126·53; density, 126·53).—This element is obtained chiefly from seaweed, but was discovered accidentally in 1812 by M. Courtois in the mother-waters of his saltpetre works, and it has since been found in combination with potassium and sodium in many mineral waters. Kelp contains it abundantly, as do also the mother-waters of the salt works upon the Mediterranean Sea; and it has been recently found in combination with silver in some ores brought from the neighbourhood of Mexico.

Iodine may be procured by drying and powdering common seaweed—sponge, for instance—and heating it with sulphuric acid; a *violet* vapour rises, which, if received in a cool vessel,

Fig. 2.



will condense on its sides, and form scaly crystals (fig. 2) of a somewhat metallic lustre. These crystals are iodine; and it is named from the violet colour of the vapour. It is most economically procured from the mother-water of kelp, as furnished by the soap manufacturers, who employ that crude alkali. The water is mixed with an excess of sulphuric acid

in a retort, and exposed to heat, when the violet vapours of iodine distil over, and may be condensed.

Iodine is always solid at atmospheric temperatures, but it slowly volatilizes, emitting a peculiar offensive penetrating odour, somewhat like chlorine. It fuses at 220° Fahr., and boils off rapidly at 350°. It enters into many combinations: two of them, the iodides of potassium and iron, are used in medicine, and another, the periodide of mercury, is a brilliant red pigment, but somewhat evanescent. But the chief use to which iodine has been put in the arts is the detection of starch, with the watery solutions of which it forms a compound of a deep purplish-blue colour. The compound of iodine with silver is the basis of the collodion process of photography, still in very general use, as well as of the original daguerreotype process. This salt is only sensitive to light when in contact with some substance capable of combining with iodine, as metallic silver or free silver nitrate.

FLUORINE (F; atomic weight, 19·1).—This element occurs combined with the meta calcium, forming calcium fluoride or fluorspar (CaF_2), a mineral found in Derbyshire. It is also found in large quantities in cryolite ($3NaF+AlF_3$), a mineral found in Greenland. Fluorine forms no compounds with oxygen, and it is extremely difficult to obtain in a pure state.

Hydrogen Fluoride or *Hydrofluoric Acid* (HF; atomic weight, 20·1).—This is obtained by heating powdered calcium fluoride with concentrated sulphuric acid in a leaden or platinum vessel, as glass is rapidly attacked by the vapour. The colourless gas thus obtained fumes strongly in air; at −20° C. it forms into a liquid. This liquid is strong aqueous hydrofluoric acid; it acts very violently upon the skin, producing painful sores; and the fumes of the gas are dangerous from their corrosive power. The most remarkable property of hydrofluoric acid is its power of etching on glass. This arises from the circumstance that fluorine forms, with the silicon contained in the glass, a volatile compound called silicon-tetrafluoride. The glass to be engraved is coated with wax, and the design traced in the usual way with a pointed instrument. A shallow basin made by bending up a piece of lead is prepared, and a little powdered fluorspar placed in it with sufficient sulphuric acid added to form a thin paste. The glass is placed upon the paste with its waxed side downwards, and gentle heat applied, which speedily disengages the vapour of hydrofluoric acid. In a few minutes the operation is completed, and on the glass being cleaned by a little warm oil of turpentine, when the experiment is successful, the lines are very clean and smooth. Fluorspar is also used in metallurgic operations as a flux.

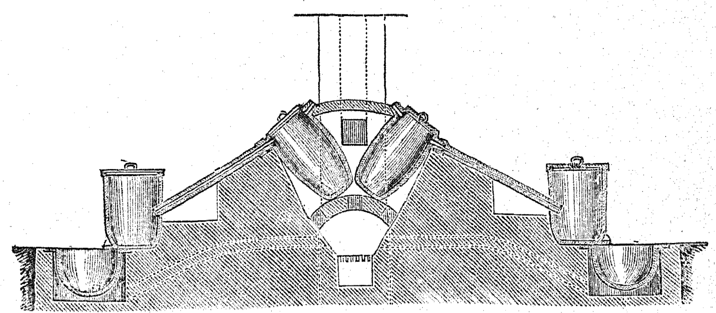
The four members of this group of elements exhibit certain relations among themselves. Chlorine is a gas, bromine a liquid, and iodine a solid, at ordinary temperatures. Again, the specific gravity of liquid chlorine is 1·33, of bromine 2·97, and of iodine 4·95. Liquid chlorine is transparent, bromine is slightly so, and iodine is opaque. The combining weight of bromine is nearly the mean of those of chlorine and iodine, and in its general chemical deportment it stands half-way between the other two elements. The property which distinguishes these substances from the rest of the elements is the power of forming with hydrogen compounds containing equal volumes of the constituent gases united without condensation.

SULPHUR (S; atomic weight, 31·98; density, 31·98).—Sulphur is one of the few elementary substances which occur in nature in a simple state. It is an abundant product in many parts of the world, especially in volcanic countries, where it is found often in a state of great purity. It occurs in amorphous masses of a glassy lustre when newly broken, and also in crystalline masses, and sometimes in complete and regular crystals in the form of rhombic octahedra. It exists in combination with many metals, forming compounds termed sulphides, which constitute the common ores from which the metals are mostly obtained, as PbS, lead sulphide or galena; ZnS, zinc sulphide or blende; and CuS, copper sulphide.

Sulphur is also found combined with metals and oxygen, forming a class of salts termed sulphates; as calcium sulphate or gypsum ($CaSO_4+2H_2O$), barium sulphate or heavy-spar ($BaSO_4$), sodium sulphate or Glauber's salt ($Na_2SO_4+10H_2O$), which occur in the largest quantity.

Sulphur also combines with hydrogen, forming the highly poisonous and offensive gas known as sulphuretted hydrogen, and which not unfrequently contaminates the coal-gas supplied to us for illumination. Sulphur and carbon also combine, and form a beautifully transparent and colourless liquid, exceedingly volatile, and giving off an odour the most fetid and nauseous which it is possible to conceive. Sulphur when strongly heated out of contact of air boils and evaporates; and the vapour emitted, condensing when its temperature is reduced by contact with any cold body, forms the bright yellow powder known as *flowers* of sulphur. It is obtained in this state by a process of distillation, the crude sulphur being put into a cast-iron retort, the beak of which is led into an air-tight chamber, where the vapour is condensed, as shown in fig. 3. When the sulphur is melted and poured into wooden moulds, it forms the yellow cylinders known as roll-sulphur.

Fig. 3.



One of these rolls held in a warm hand emits a crackling noise by the fracture of its interior parts, and at length breaks in pieces. When rubbed it emits a peculiar well-known smell, and becomes at the same time negatively electric.

Sulphur exists in three modifications, one in its natural crystallization, and the other two are obtained by melting sulphur. If melted sulphur is cooled slowly it crystallizes in long, transparent, needle-shaped, prismatic crystals, quite different in form from the natural crystals, and having a specific gravity of 1·98, the specific gravity of the crystals of native sulphur being 2·07. The third allotropic modification of sulphur is obtained by pouring melted sulphur at 230° C. into cold water, when it forms a soft tenacious mass, and has a specific gravity of 1·96. This form of sulphur is, however, not permanent, as in a few hours at ordinary temperatures the mass assumes its ordinary brittle form. Sulphur is an inflammable substance, and burns in air with a bluish flame, combining with the oxygen to form sulphur dioxide (SO_2), which is given off as a gas possessing a peculiar and suffocating smell. Sulphur is insoluble in water, but both the natural variety and the crystalline variety dissolve readily in carbon bisulphide (CS_2). The tenacious form of sulphur is insoluble in this liquid.

Compounds of Sulphur and Oxygen.—Sulphur forms with oxygen two compounds or oxides which give rise to acids when they are brought into contact with water—namely, sulphur dioxide and sulphur trioxide.

Sulphur Dioxide (SO_2; atomic weight, 63·9; density, 31·95).—This gas is the only product of the combustion of sulphur in dry air; it is given off in large quantities from volcanic craters. It is readily obtained by heating sulphuric acid with metallic mercury or copper clippings.

$$\underset{\text{Sulphuric Acid.}}{2H_2SO_4} + \underset{\text{Copper.}}{Cu} = \underset{\text{Copper Sulphate.}}{CuSO_4} + \underset{\text{Sulphur Dioxide.}}{SO_2} + \underset{\text{Water.}}{2H_2O}.$$

The gas given off is a colourless gas, with a suffocating smell of burning sulphur; it is 2·211 times heavier than air, and may be condensed to a colourless liquid at −8° C. under

ordinary atmospheric pressure. At -76° C. the liquid becomes a transparent solid. The volume of this gas formed by the combustion of sulphur is exactly the same as that of the oxygen employed, and as the density of sulphur dioxide is 31·95, it contains equal weights of its constituent elements, one volume of sulphur uniting with two volumes of oxygen to give two volumes of the dioxide. Sulphur dioxide is very soluble in water, one volume of water at 10° C. dissolving 51·38 volumes of this gas.

Sulphurous acid is the hydrogen salt of a series of compounds termed *sulphites.* It is largely used as a bleaching agent for silk and woollen fabrics, which cannot be bleached by chlorine. It is likewise used as an antichlor for getting rid of the excess of chlorine present in the bleached rags employed for paper-making. In its bleaching action it operates in a manner exactly opposite to that in which chlorine does. It unites with the oxygen of the water or colouring matter present, forming sulphuric acid and liberating the hydrogen, so that it bleaches by acting as a deoxidizing agent. The great value of sulphur dioxide is in the manufacture of sulphuric acid. Sulphurous acid (H_2SO_3), like carbonic acid (H_2CO_3), contains two atoms of hydrogen, both of them being capable of being replaced by metals.

Sulphur Trioxode (SO_3; atomic weight, 79·86; density, 39·93).—Sulphur trioxide may be formed directly by passing a dry mixture of sulphurous oxide and oxygen gases over heated and finely divided metallic platinum; union takes place, and dense white fumes of sulphur trioxide are evolved, condensing into long prismatic crystals melting at 16° C. and boiling at 46° C. The trioxide yields a colourless vapour which on passing through a red-hot tube is decomposed into two volumes of sulphur dioxide and one volume of oxygen. Sulphur trioxide does not redden litmus paper, and if brought into contact with water, the two substances combine with great force and a hissing noise, and form sulphuric acid (H_2SO_4).

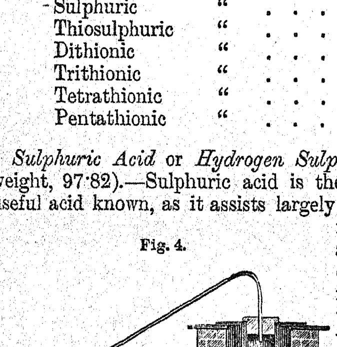
Besides sulphur dioxide and sulphur trioxide, which yield respectively sulphurous acid (H_2SO_3) and sulphuric acid (H_2SO_4), there is an oxide (S_2O_3) and eight other oxy-acids of sulphur known, of which sulphurous acid, sulphuric acid, and thiosulphuric acid are important compounds. The remaining five do not, as yet, serve any purpose in the arts or manufactures.

OXY-ACIDS OF SULPHUR.

Hyposulphurous acid, ...	H_2SO_2.
Sulphurous "	H_2SO_3.
Sulphuric "	H_2SO_4.
Thiosulphuric "	$H_2S_2O_3$.
Dithionic "	$H_2S_2O_6$.
Trithionic "	$H_2S_3O_6$.
Tetrathionic "	$H_2S_4O_6$.
Pentathionic "	$H_2S_5O_6$.

Sulphuric Acid or *Hydrogen Sulphate* (H_2SO_4; atomic weight, 97·82).—Sulphuric acid is the most important and useful acid known, as it assists largely in the preparation of nearly all the acids; and it is also very extensively employed in various manufacturing processes. It was first obtained by distilling a compound of iron, oxygen, sulphur, and water, termed ferrous sulphate or green vitriol, in apparatus similar to that shown in fig. 4. The acid obtained is known as fuming or Nordhausen acid, and consists of a mixture of hydrogen sulphate and sulphur trioxide ($H_2SO_4 + SO_3$). The present method of preparing the acid depends upon the fact that although sulphur dioxide does not combine with free oxygen and water to form sulphuric acid, it will take up the oxygen when the latter is united with nitrogen in the form of nitrogen trioxide (N_2O_3).

Fig. 4.



$$\underset{\text{Sulphur Dioxide.}}{SO_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Nitrogen Trioxide.}}{N_2O_3} = \underset{\text{Sulphuric Acid.}}{H_2SO_4} + \underset{\text{Nitric Oxide.}}{N_2O_2}.$$

This process, in manufacturing upon a large scale, is carried on in chambers made of sheet lead, with a capacity of from 50,000 to 100,000 cubic feet, and supported on wooden beams. These leaden chambers are connected together by a wide leaden passage. On the outside, at one end, a small furnace or oven is built, having a wide tube leading into the chamber. In this oven sulphur is kept burning, the flame of which heats a crucible containing a mixture of nitre and oil of vitriol. The floor of the chambers are occupied by a shallow stratum of water, and a steam jet is likewise introduced. An exit is constructed at the far end of the chambers for the escape of the spent and useless gases. By these arrangements a constant supply of sulphurous oxide, atmospheric air, nitric acid vapour, and water in the state of steam are thrown together in the chambers to mix and react upon each other. The sulphuric acid as it forms falls on to the floor of the chambers, from whence it is continually drawn off. In order to obtain from this weak chamber acid the pure sulphuric acid (H_2SO_4), the excess of water is removed by evaporation in covered leaden pans until the specific gravity rises to 1·72, at which stage it forms the brown oil of vitriol of commerce. It is afterwards further concentrated in glass vessels, as lead is attacked by the strong acid, until its maximum strength and specific gravity are attained. Its specific gravity at 0° C. is 1·854. It combines with water with great energy, absorbing moisture rapidly from the air. In mixing this acid with water great heat is evolved, and care should be taken to bring the two liquids gradually together, otherwise an explosive combination may be formed. Several organic bodies, as sugar, woody fibre, &c., are completely decomposed and charred by strong sulphuric acid. Others, as alcohol, oxalic acid, &c., are split up into other compounds by the removal of the elements of water by this acid.

Sulphuric acid acts readily on metallic oxides, converting them into sulphates. It also decomposes carbonates, expelling carbon dioxide with effervescence. By the aid of heat it decomposes all other salts containing acids more volatile than itself. The sulphuric acid of commerce often contains large quantities of impurities—lead, arsenic, nitric acid, and the lower oxides of nitrogen.

Thiosulphuric Acid ($H_2S_2O_3$).—This acid does not occur in the free state. Its compound with sodium is largely employed in photography for the purpose of fixing the image, the salt possessing the property of dissolving the silver salts which have been unacted on by the light. It is commonly known as hyposulphite of soda (the acid having been formerly named *hyposulphurous acid*), and is obtained by passing a current of sulphur dioxide into a mixed solution of sodium sulphide and caustic soda, and purifying by crystallization. The sodium thiosulphate is thus obtained:

$$2Na_2S + 2NaOH + 4SO_2 = 3Na_2S_2O_3 + H_2O.$$

Compounds of Sulphur and Hydrogen.—There are two: hydrogen sulphide and hydrogen disulphide.

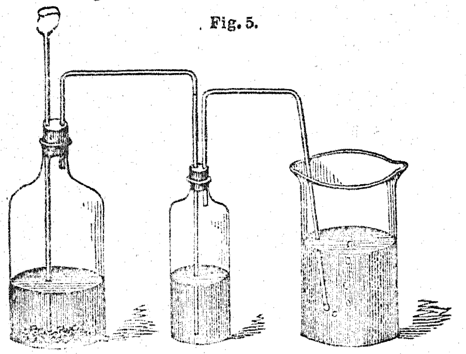
Hydrogen Sulphide or *Sulphuretted Hydrogen* (H_2S; atomic weight, 33·98).—This gas occurs free in nature in volcanic gases, as well as in the water of certain springs. The peculiar odour and medicinal property of the Harrogate waters is due to the presence of this gas. It is also generated by the putrefaction of animal matters, the white of egg, which contains sulphur, and by the dioxidation of sulphates in presence of decaying organic matter. It is a colourless gas, with the odour of rotten eggs. When inhaled it acts as a poison on the animal economy, although diluted with large quantities of air. This gas is obtained readily by the action of dilute sulphuric acid upon iron sulphide (FeS), iron sulphate being likewise formed:—

$$FeS + H_2SO_4 = FeSO_4 + H_2S.$$

The most convenient method of procuring this gas consists

in adding dilute sulphuric acid to iron sulphide, placed in a bottle, closed with a cork, perforated with two holes, one for the passage of a tube funnel, through which sulphuric acid can be poured; while through the other is passed a tube for the exit of the gas (fig. 5). When the sulphide is introduced

Fig. 5.



the cork should be put in its place, and the requisite quantity of dilute acid poured down the funnel; if the sulphide be good, a stream of gas bubbles will immediately begin to rise, and passing through the exit tube can be directed through any solution, or to any required point.

One volume of water at 0° C. dissolves 4·37 volumes of the gas, and at 15° C. 3·23 volumes are soluble. At a temperature −62°C. it condenses to a colourless fluid, and freezes to a transparent mass at −85° C. Sulphuretted hydrogen is an invaluable reagent, as by its means the metals are enabled to be separated into groups: those which are precipitated by sulphuretted hydrogen from an acid solution, or the copper group; those which are not precipitated by sulphuretted hydrogen in an acid solution, but which are precipitated in an alkaline one, or the iron group; and those which are in no case precipitated by this reagent, as their sulphides are soluble either in water, acids, or alkalies, as the metals of the alkalies and alkaline earths.

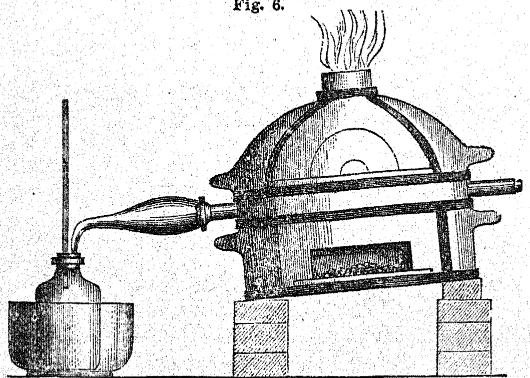
Hydrogen disulphide (H_2S_2) is obtained by pouring a solution of calcium disulphide into hydrochloric acid:—

$$CaS_2 + 2HCl = H_2S_2 + CaCl_2.$$

An oily liquid falls to the bottom, which is hydrogen disulphide; it closely resembles hydrogen dioxide in many of its properties; it has a peculiar smell, bleaches, and is easily decomposed into sulphur and sulphuretted hydrogen.

Carbon Disulphide (CS_2; atomic weight, 75·93; density, 37·96).—When the vapour of sulphur is passed over red-hot charcoal, as in the apparatus shown in fig. 6, a volatile compound, CS_2, is formed, which may be condensed to a heavy colourless liquid, possessing usually a very dis-

Fig. 6.



agreeable smell, boiling at 46° C., and having a specific gravity of 1·292. It is very inflammable, its vapour igniting at 149° C. when mixed with air, forming carbon dioxide and sulphur dioxide. It is insoluble in water, but is a solvent of gums, caoutchouc, sulphur, and phosphorus. Its vapour is very poisonous, and it requires great caution in its use. When perfectly pure it has a pleasant smell.

When the sulphur compounds are compared with the corresponding bodies in the oxygen series, a remarkable analogy is presented, not only in composition, but in their similar chemical properties, and similar relations are seen in many other compounds of sulphur and oxygen.

Water, H_2O.	Sulphuretted hydrogen, H_2S.
Hydrogen dioxide, H_2O_2.	Hydrogen disulphide, H_2S_2.
Carbon dioxide, CO_2.	Carbon disulphide, CS_2.

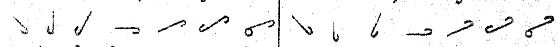
SHORTHAND.—CHAPTER V.

FINAL HOOKS—CIRCLE S—ST-LOOP—THEIR FORMS, USES, AND COMPOUNDS.

The student will have noted in the preceding chapter the explanation given of the initial hooks, adding *l* and *r*. There are also final hooks adding *f*, *v*, and *sion*, *tion* (*shon*). When a final hook is placed on the left side of a straight line representing a consonant, it indicates the addition of *n* to the consonant signified; but if the final hook is placed on the right side it adds *f* to the preceding consonant.

FINAL HOOKS.

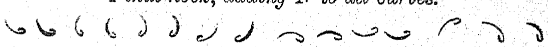
Final hook, adding N. | *Final hook, adding F or V.*



pn, tn, chn, kn, rn, wn, hn. | pf, tf, chf, kf, rf, wf, hf.

To every consonant, simple or compound, formed by a curved line final hooks may be added in the mode exhibited in the following arrangement, viz.—

Final hook, adding N to all curves.



fn, vn, thn, *th*n, sn, zn, shn, zhn, mn, mpn, nn, ngn, ln, rn, rchn.

There is no *f* or *v* hook to curved letters.

A large final hook—technically called the *shon* hook—is used to represent the termination *tion*, *shion*, *sian*, *sion* (pronounced *shon*). This hook can be added to both straight and curved strokes; as—

fashion, *mission*, *passion*, *auction*, *cushion*.

When the *tion* hook follows a curve it is written on the inner side like the final *n* hook noted above. At the end of a straight line (1) beginning with a hook, (2) a circle, or (3) springing from a curve, the *tion* hook when final is written on the opposite side that the straightness of the letter may be preserved; as—

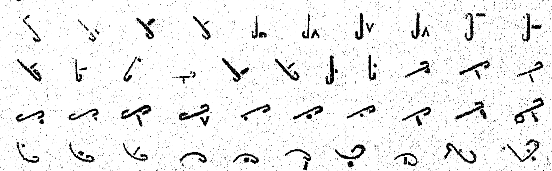
oppression, *collection*, *affection*, *selection*.

In other cases, however, *tion* when final and following a straight-line letter is written on the opposite side to that on which the vowel (or accented vowel if more than one occurs) is placed, thus:—

passion, *caution*, *diction*, *operation*.

After *t* or *d*, not preceded by a hook, circle, or loop, the *tion* hook is always written on the right side; as in , addition.

The following exercise on the final hooks should be carefully copied several times, writing out the words represented by the characters:—



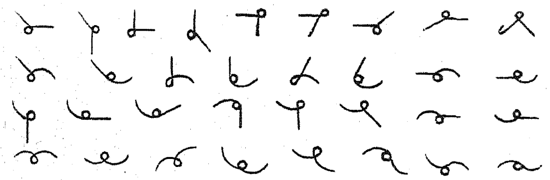
The student may now advantageously practise the writing of the following words, referring to the directions given in any case of doubt or difficulty:—action, faction, paction; lection, section; diction, fiction; suction, nation, ration, station; lotion, notion, motion, potion; conversion, diversion, perversion; vision, division, prevision, provision, excision; addition, condition, monition, munition, punition, fruition, exhibition, inhibition, &c.

We now proceed to explain a very important part of Pitman's ingenious system of phonography, namely, that which provides additional signs for *s* and *z*, or the sound of *z*. This is given on account of the very great frequency with which the sounds of *s* and *z* occur (1) initially, (2) medially, and (3) finally. This important sibilant is represented by a small circle, ○, which is used to represent either of the letters *s* and *z*.

(1) The simplest form of employing the *s* or *z* sign (circle ○) is provided for use when it is required between two consonants.

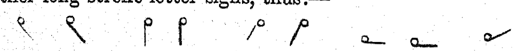
It is important, however, here first to observe that a vowel cannot be read either before, after, above, or below the circle sign for *s* or *z*, that is to say, the vowel occurring in a word where this circle is used must be read either before or after the consonant to which the circle sign for *s* or *z* is joined.

The student, after carefully noting the various forms of composition in which this circle sign is joined, should practise the following exercise carefully, so as to attain the ability to form the circle neatly and rapidly, particularly giving attention to the manner in which the circle is formed, and the relation it holds to the other letters with which it is joined:—



The circle is turned on the right side, between *t* or *d* and *k* or *g*, to express *kr*, *gr*; thus, *descry*, *disgrace*.

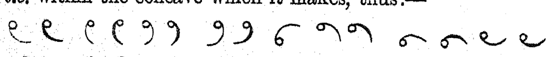
(2) This circular sign for *s* is prefixed to straight-line letters by forming the small circle on the right side of *t* and *d*, and on what is practically the corresponding side of all other long stroke-letter signs, thus:—



sp, sb; st, sd; sch, sj; sk, sg; sr.

Exercise.—Write star, stain, stair, stab, stall, stave, stove, stir, storm, still, stem, stitch, stand, staunch, strife, sad, said, sod, side, sedge, sudden, spar, spare, spur, spurn, spore, sport, sperm, spring, sob, sop, soup, subtile, subject, ask, bask, cask.

(3) In the case of curve-formed letters, in whichever way they are struck, the circle *s* is written in the inner side, *i.e.* within the concave which it makes, thus:—



sf, sv; sth, *sth*; ss, sz; ssh, szh; sl; sr, srch; sm, smp; sn, sng;

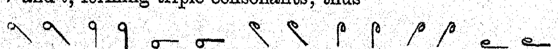
as in *safe*, *save*, *south*, *seize*, *slay*, *sir*, *seem*, *seen*, *snow*, *sing*.

Exercise.—Write safe, soft, suffer, south, saith, sly, slip, slain, sleep, sir, sire, sure, search, smash, simple, sunny, sung, snore, snort, single, sluggard.

(4) When the sign for circle *s* is prefixed to the double consonantal letter *kw* it is written twice the ordinary size; as *sk*, *skw*, as in *squirrel*, *square*.

Exercise.—Write skin, skewer, askew, squirt, squeeze, squander, squalor, squeamish.

In addition to the foregoing four simple methods of using the sign for circle *s* or *z*, it may be prefixed to the hooks *r* and *l*, forming triple consonants; thus



spr, sbr; str, sdr; skr, sgr: spl, sbl; stl, sdl; schl, sjl; skl, sgl;

Exercise.—Write spray, sprite, spring, string, strength, skirmish, scrub.

It will readily be noticed that this is accomplished by forming the *pr*, &c., into a circle on the left side of the circle; but it must here be stated, as a precaution requiring attention, that *stl*, *skl*, &c., are formed by adding the circle in the inner side of the hook, because the circle on the left side is already allocated to the representing of *st*, *sp*, *sk*.

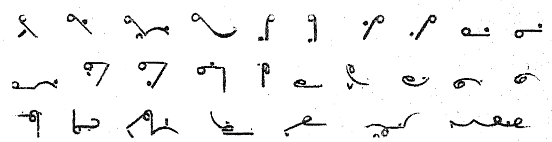
The circle *s* is added to the *fr*, *fl* series in the same manner, thus:—

sfr, *nr*, *snr*, *mr*, *smr*.

S is prefixed to *w* thus, *sw*, as in *sweep*, *swear*.

As there are no English words containing the sounds which the signs *schr* and *srr* would represent, these signs are made to do duty for *h*. Sometimes these triple consonants occur medially, as in *destroy*, *display*, *disclose*, after circle ○, and sometimes therefore a perfect hook cannot be formed. In such cases an imperfect one will be found practically to suffice, as in the examples annexed, viz. *explain*, *rascal*.

The following exercise illustrates the various uses of the initial and medial circle *s*, and we would urge upon the student to bestow much care on this exercise:—



children, *sway*, *civil*, *prisoners*, *cattle*.

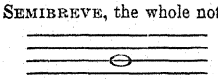
The circle *s*, lengthened to a loop half as long as a consonant, represents *st*. It is used initially thus, *stop*, *stuff*, *state*, *stage*, *stick*, *store*, *story*, *stale*.

MUSIC.—CHAPTER V.

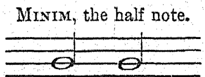
MUSICAL NOTES IN SCALE—RESTS—EXERCISES IN VARIOUS KEYS—THE TUNING FORK—SHARPS AND FLATS.

The student has now reached that point at which we may, with propriety, place before him what may be called a musical time table. It will help him to gain a true conception of the relations between one note and another if he consider the notes to possess the following respective proportions, viz.:

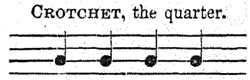
Semibreve, the whole note.



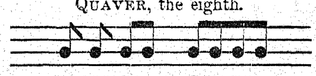
Minim, the half note.



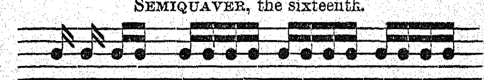
Crotchet, the quarter.



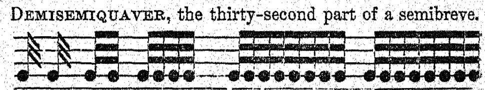
Quaver, the eighth.



Semiquaver, the sixteenth.



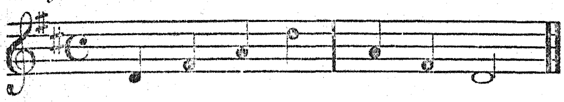
Demisemiquaver, the thirty-second part of a semibreve.



The whole of what is indicated in the foregoing table of musical notes may be summed up thus:—One semibreve is equal to two minims, four crotchets, eight quavers, sixteen semiquavers, or thirty-two demisemiquavers. Conversely the minim is half a semibreve, the crotchet half a minim or the fourth part of a semibreve, the quaver one half of a crotchet or the fourth of a minim, the eighth of a semibreve, &c.

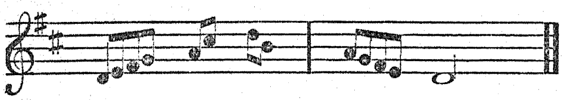
The following short exercise should be practised in the three modes previously mentioned. Let the various lengths of the notes be carefully observed, A, B, and C being sung in exactly the same time.

Key D. A.



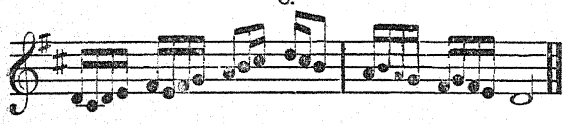
| d :m | s :d' | s :m | d :— ||

B.

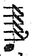


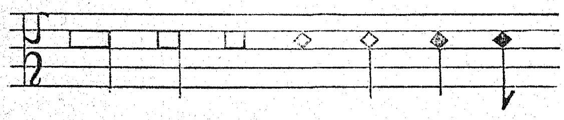
| d .r :m.f | s .t :d'.l | s .f :m.r | d :— ||

C.



| d,t_1.d,r:m,r.m,f | s.l,t:d',t.l | s,l.s,f:m,f.m,r | d:— ||

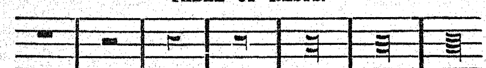
Occasionally in Sacred Music the breve  which is double the length of a semibreve, is used; and in very rapid instrumental music the semidemisemiquaver,  which is only the sixty-fourth part of a semibreve, is adopted, though these two notes are seldom required. It may be mentioned, too, that in the earliest written music, notes of other shapes and values were employed. The notation during the fifteenth and sixteenth centuries was of the following form, and was written on a stave varying from four to six lines:—



Large. Long. Breve. Semi-breve. Minim. Semi-minim. Croma.

The semibreve, which is now taken as our whole note, was then one of the shortest, and was used in light music only.

TABLE OF RESTS.



Semi-breve. Minim. Crotchet. Quaver. Semi-quaver. Demisemi-quaver. Semidemi-semiquav.

In tonic sol-fa the same time relation of the different notes, as given in page 560, would be exhibited thus:—

Four Pulse-note, corresponding to Semibreve.

| d :— | — :— ||

Two Pulse-note, corresponding to Minim.

| d :— | d :— ||

One Pulse-note, corresponding to Crotchet.

| d :d | d :d ||

Half Pulse-note, corresponding to Quaver.

| d .d :d .d | d .d :d .d ||

Quarter Pulse-note, corresponding to Semiquaver.

| d ,d .d ,d :d ,d .d ,d | d ,d .d ,d :d ,d .d ,d ||

Eighths of a pulse-note, corresponding to Demisemiquaver.

| dd,dd.dd,dd:dd,dd.dd,dd | dd,dd.dd,dd:dd,dd.dd,dd ||

It will be seen that in this notation there is no special sign for eighths of a pulse. Two eighths are simply written in the space that would be allotted to one quarter, and sixteenths, corresponding to demisemiquavers, would be represented in the same manner.

To assist the learner Mr. Curwen, towards the close of his useful and successful career, adapted from the French a language of musical time which is now much used. It proceeds on the principle that by speaking the given time-name a true conception of the duration required for any note will be obtained. For the sake of those who may prefer to use these names, or who may wish to know what they may mean and their value in music, we give the following—

TONIC SOL-FA TIME CHART.

By John Curwen.

Wholes. Halves.	Quarters.	Thirds.
:1 TAA-AI or TAA	:1 ,1 .1 ,1 tafatefe	:1 ,1 ,1 taataitee
:— -AA-AI or -AA	:1 .1 ,1 TAAtefe	:1 ,- ,1 taa-aitee
: *SHAA-AI* or *SHAA*	:1 .,1 TAA-efe	:1 ,1 ,- taatai-ee
:1 .1 TAATAI	:1 ,1 .1 tafaTAI	: ,1 ,1 *saa*taitee
:- .1 -AATAI	: ,1 .1 ,1 *sa*fatefe	:1 ,— , taa-ai*see*
: .1 *SAA*TAI	:1 ,1 .1 , tafate*se*	:1 , , taa*sai-ee*
:1 . TAA*SAI*	:1 . ,1 TAA*se*fe	:1 , ,1 taa*sai*tee

Eighths.	:11,11.11,11 tanafanatenefene	Sixths. 3 accents.	:11,11,11 tafatefetifi
Ninths.	3 3 3 :111,111'111 taralatereletirili	Sixths. 2 accents.	3 3 :111.111 taralaterele

Note.—"Ai" is pronounced as in m*ai*d, f*ai*l, &c. "Aa" is pronounced as ā in f*a*ther, "a" as in m*a*d, "e" as in l*e*d, and "i" as in l*i*d. When it is desired to show the strong accent the letter "r" is inserted thus, "traa-ai," "traatai," &c. When there is need to express the medium accent the letter "l" is inserted in a similar way. These time-names are copied from M. Paris' "Langue des durées." The more minute divisions are seldom used except in instrumental music. In the Tonic Sol-fa notation we often write *two* measures in the place of *one* in the common notation, thus expressing the accent more truly than it does.

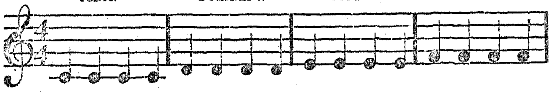
It should also be explained that although for the ordinary notation we have here adopted the German method, yet the crotchet is not always taken to represent one pulse or beat of a measure. A minim is occasionally employed for that purpose, and not unfrequently a quaver stands as the aliquot part.

We are now in a position to have scale and chord exercises of a more interesting and melodious character than those given in the earlier stages of our studies. In practising those that immediately follow the student should endeavour to give each vowel its exact sound, and ought to see that the tones are well formed and delivered without obstruction from lips, tongue, or teeth. Let the throat be freely opened, the

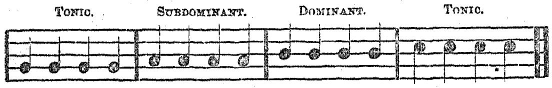
lungs well inflated and rightly filled, and the breath held back and kept thoroughly under command. The names, tonic, &c., show the chords (see p. 269) by which the exercises may be accompanied.

Key C. **Exercise 72.** GEO. F. ROOT.

TONIC. DOMINANT. TONIC. SUBDOMINANT.

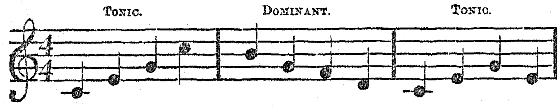


{|d :d |d :d |r :r | r :r |m:m|m:m|f :f |f :f }
Oh ah a e | oh ah a e | oh ah a e | oh ah a e

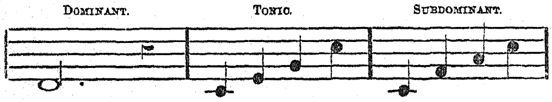
TONIC. SUBDOMINANT. DOMINANT. TONIC.

{|s :s |s :s|l :l |l :l |t :t |t :t |d' :d' |d' :d' ||
Oh ah a e | oh ah a e | oh ah a e | oh ah a e

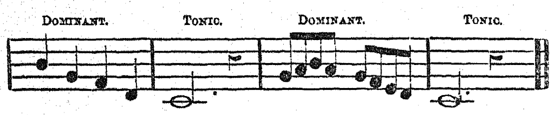
Key C. **Exercise 73.** ROOT.

TONIC. DOMINANT. TONIC.

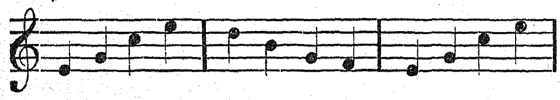


{|d :m |s :d' |t :s |f :r |d :m |s :m }
Ah - - - - - - - - - - - - - | Ah - - - - - -

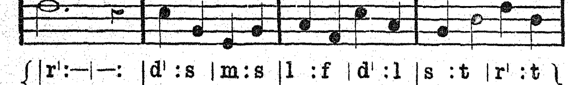
DOMINANT. TONIC. SUBDOMINANT.

{|r :— |— : |d :m |s :d' |d :f |l :d' }
- - - - - - | Ah - - - - - - | - - - - - - -

DOMINANT. TONIC. DOMINANT. TONIC.

{|t :s |f :r |d :— |— : |s.l:t.l|s.f:m.r|d :— |— : ||
Ah - - - | - - - - | Ah - - - - - - | - - - -

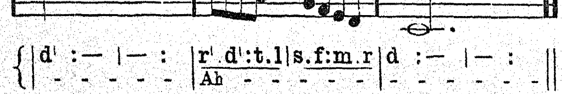
Key C. **Exercise 74.** GEO. F. ROOT.



{|m :s |d' :m' |r' :t |s :f |m :s |d' :m' }
Ah - - - - - - - - - - - - - | Ah - - - - - -



{|r':—|—: |d' :s |m :s |l :f |d' :l |s :t |r' :t }
- - - | Ah - - - | - - - - - - | Ah - - - -

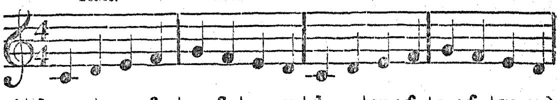


{|d' :— |— : |r'.d':t.l|s.f:m.r|d :— |— : ||
- - - - - - | Ah - - - - - - | - - - - - -

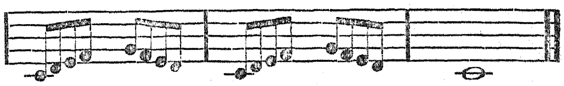
Exercise 74 can be accompanied with the same chords as Exercise 73. From the Italian language, so soft and beautiful in itself, we may obtain great assistance in arriving at a correct delivery of the different vowels. In the two exercises that follow, taken by permission from "Principles of Singing" by A. B. Bach, let it be observed that *a* sounds *ah*, *e* sounds *ae*, while *i* sounds *ee*.

Key C. **Exercise 75.**

TONIC. DOMINANT. TONIC, &c.



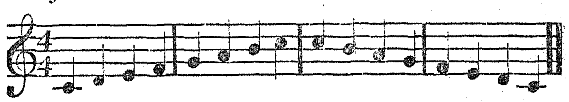
{|d :r |m : f |s :f |m :r |d :r |m :f |s :f |m:r }
A - do - ra - ta | ca - ra ma-dre | a - do - ra - ta | ca - ra ma-dre.



{|d.r:m.f|s.f:m.r|d.r:m.f|s.f:m.r|d :— |— :—||
A
E
O
I
U

The previous exercise should also be sung in the other keys, ascending to F.

Key C. **Exercise 76.**



{|d :r |m :f |s :l |t :d' |d' :t |l :s |f :m |r :d ||

1. A - ma - te - mi so - rel - li - na a - ma - te - mi sol - rel - li - na.
2. A - mo - li - mio buon-fra-tel-lo a - mo - il - mio buon-fra-tel - lo.

The above should be sung in successive keys up to E.

Familiarity with the seven tones of the scale ought now, in some degree at least, to have been gained, and from experience it must have been learned that while the pitch at which the scale is sung varies with every new key-name, the scale itself remains the same. It is like singing the same tune sometimes high and sometimes low—the tune itself is never altered, the key or pitch at which it is sung alone undergoes a change.

To enable the student to fix Doh, the key-tone, at any required pitch, it is now necessary to explain that middle C (p. 468) is taken as the standard of pitch, and it is from this given sound that we measure all the others. The instrument called a C tuning fork produces a sound an octave higher than middle C. In using it the prongs are, by a blow or by pressure, made to vibrate; the voice catches up the sound thus produced, and descending the scale, using the letter names (p. 468), dwells upon the key-sound desired, transforming the letter name, as A, B, E, F, &c., into the key-name Doh. Suppose, for example, that the piece of music we intend to sing is written in the key of F, we take the sound C' from the tuning fork, and running down the scale C B A G F (equal to **d' t l s f**), the voice dwells for a time on F, which sound we make our *Doh*. To put ourselves in tune for singing in that key it would be well to supplement the fixing of the sound of Doh by singing the complete tonic chord. If the tone E were required for Doh we would proceed as before, going only half a tone lower; thus—

C' B A G F E — — — | **d : m : s | d' : — | —** ||

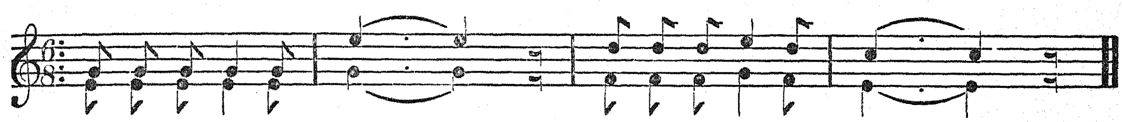
For the key of D we would simply descend one tone lower for our key-sound. It should be carefully observed that in descending thus with the letter names the semitones come as with the syllables, and that the letter names, as thus used, spell the words "bag" and "fed."

In the specimen pieces which follow, the position of Doh on the staff is varied as much as possible, that the student may be enabled by practical experience to strike the different distances, or intervals, as they are called, in any key. For the sake of those who use the sol-fa system only the key-name will still be given, but the student of the ordinary notation will always be able to find in which key his music is written if he remembers the following rules, viz:—(1) Where-

there is neither a sharp (♯) nor a flat (♭) at the beginning of a piece of music, the key must be C or its relative minor A. This will afterwards be fully explained. (2) In keys with one or more sharps in the signature the last sharp is always on Te, the leading note; Doh must therefore be the note immediately above this last sharp. For example, in the key of G we have a sharp (♯) on F; in the key of D two sharps are required, the latter of which is on C. In both cases, indeed in every case, Doh will be found a semitone above the last sharp. (3) In keys with flats the last flat is always on Fah. Thus in the key of F there is a flat on B, which is Fah to F. With the key of B♭ (flat) we have two flats, the latter of which is on E, which is Fah to B, and so with the other flat keys.

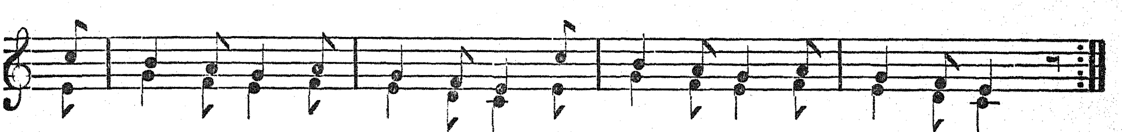
Exercise 77.—Duet—BEAUTIFUL MONTH OF MAY.

Key C. *Fine.* T. F. S.



```
{|s  :s  :s  |s  :— :s  |m' :— :— |— :— : |r' :r' :r' |m' :— :r' |d' :— :— |— :— : ||
{|m  :m  :m  |m  :— :m  |s  :— :— |— :— : |f  :f  :f  |s  :— :f  |m  :— :— |— :— : ||
```

Beau-ti - ful month of May, Beau-ti - ful month of May,



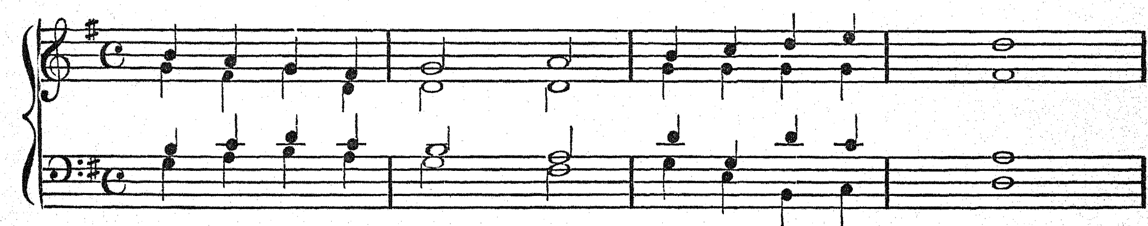
D.C.

```
{:d' |t :— :l |s :— :l |s :— :f |m :— :d' |t :— :l |s :— :l |s :— :f |m :— : ||
{:m  |s :— :f |m :— :f |m :— :r |d :— :m  |s :— :f |m :— :f |m :— :r |d :— : ||
```

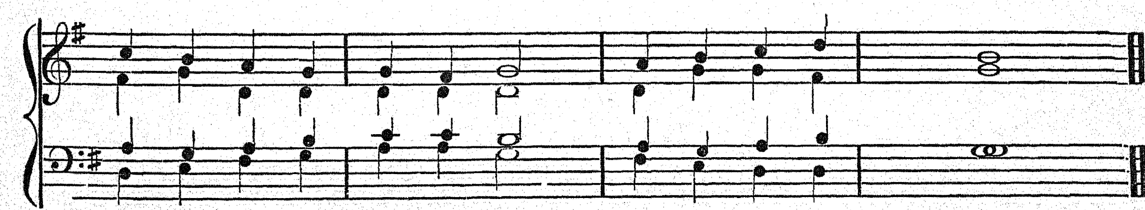
'Tis then the flow'rs be - gin to bloom, And blos - soms shed a sweet per - fume;
Oh how I love thy skies so blue, Thy lil - lies and thy vio - lets too.

Exercise 78.—Four Parts—Short Score—GOD IS NEAR.

Key G. Jas. Sneddon, Mus. Bac.



```
{|m  :r  |d  :t, |d  :— |r  :— |m :f  |s  :l  |s  :— |— :— }
{|d  :t, |d  :s, |s, :— |s, :— |d :d  |d  :d  |t, :— |— :— }
{|m  :f  |s  :f  |m  :— |r  :— |s :d  |s  :f  |r  :— |— :— }
{|d  :r  |m  :r  |d  :— |t, :— |d :l, |m, :f, |s, :— |— :— }
```

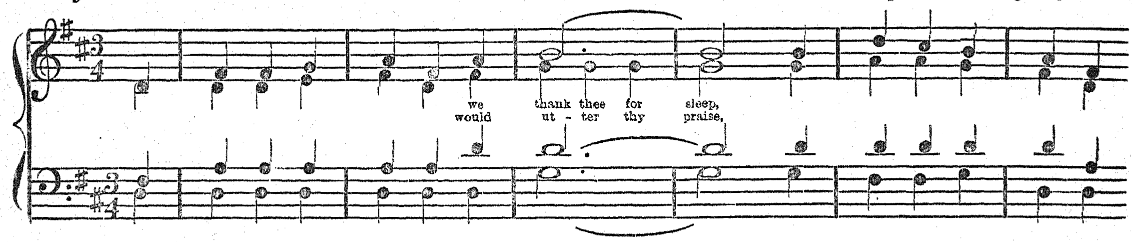
1. God is al - ways near me, Hear - ing what I say;
2. God is al - ways near me; In the dark - est night,
3. God is al - ways near me, Though so young and small;

```
{|f  :m  |r  :d  |d  :t, |d  :— |r  :m  |f  :s  |m :— |— :— ||
{|t, :d  |s, :s, |s, :s, |s, :— |s, :d  |d  :t, |d :— |— :— ||
{|r  :d  |r  :m  |f  :f  |m  :— |r  :d  |r  :m  |d :— |— :— ||
{|s, :l, |t, :d  |r  :r  |d  :— |t, :l, |s, :s, |d :— |— :— ||
```

Know-ing all my thoughts and deeds, All my work and play.
He can see me just the same, As by noon - day light.
Not a look or word or thought, But God knows it all.

Exercise 79.—MORNING HYMN.

T. F. SEWARD.
Adapted and arranged by J. S.

Key D.



:d |m :m :f |s :m :s |l :— :— |— :— :l |d' :t :l |s :m

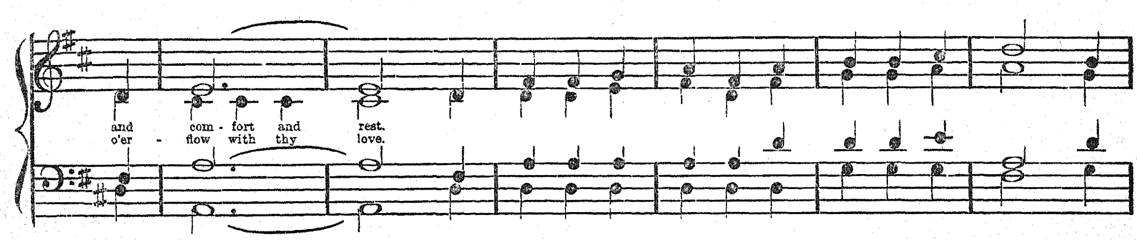
:d |d :d :r |m :d :m |f :f :f |f :— :f |s :s :f |m :d

we thank thee for sleep,
would ut - ter thy praise,

:m |s :s :s |s :s :d' |d' :— :— |— :— :d' |d' :d' :d' |d' :s

:d |d :d :d |d :d :d |f :— :— |— :— :f |m :m :f |d :d

1. Our Fa - ther, we thank thee for sleep, For qui - et, and com - fort,
2. Our voi - ces would ut - ter thy praise, Our hearts would o'er - flow with



:d |r :— :— |— :— :d |m :m :f |s :m :s |l :l :t |d' :— :l

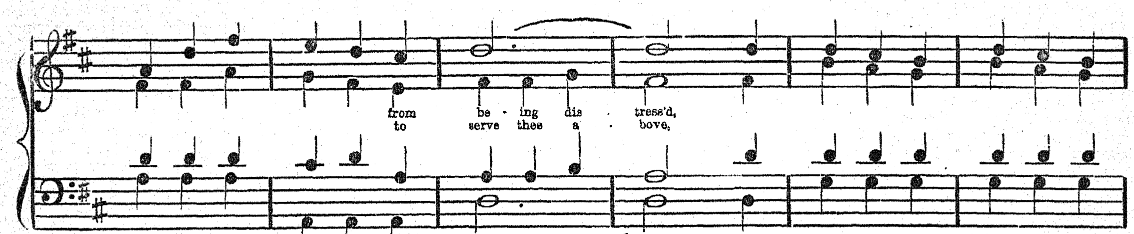
:d |t, :t, :t, |t, :— :d |d :d :r |m :d :m |f :f :s |s :— :f

and com - fort and rest.
o'er - flow with thy love.

:m |s :— :— |— :— :m |s :s :s |s :s :d' |d' :d' :r' |s :— :d'

:d |s, :— :— |— :— :d |d :d :d |d :d :d |f :f :f |m :— :f

and rest; Our Fa - ther, we thank thee for lov - ing to keep Thy
thy love; Our Fa - ther, O teach us to walk in thy ways, And



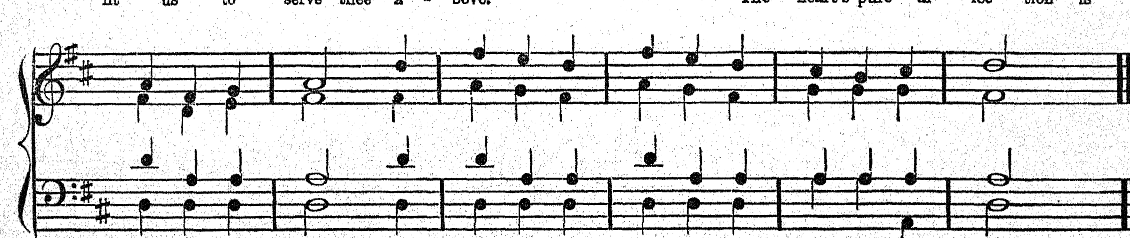
s :d' :m' |r' :d' :t |d' :— :— |— :— :d' |d' :t :l |d' :t :l

m :m :s |f :m :r |m :m :f |m :— :m |l :s :f |l :s :f

from be - ing dis - tress'd.
to serve thee a - bove.

d' :d' :d' |t :d' :s |s :s :l |s :— :d' |d' :d' :d' |d' :d' :d'

s :s :s |s, :s, :s, |d :— :— |— :— :d |f :f :f |f :f :f

chil - dren from be - ing dis - tress'd. O how in their weak - ness can
fit us to serve thee a - bove. The heart's pure af - fec - tion is

s :m :f |s :— :d' |m' :r' :d' |m' :r' :d' |t :l :t |d' :—

m :d :r |m :— :m |s :f :m |s :f :m |f :f :f |m :—

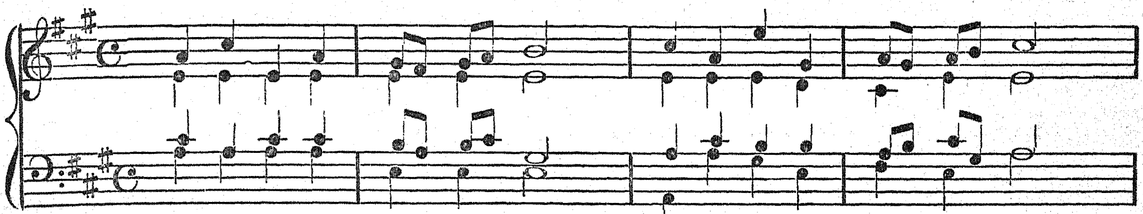
d' :s :s |s :— :d' |d' :s :s |d' :s :s |s :s :s |s :—

d :d :d |d :— :d |d :d :d |d :d :d |s :s :s, |d :—

crea - tures re - pay, Thy Fa - ther - ly kind - ness by night and by day.
all we can give. In love's pure de - vo - tion O help us to live.

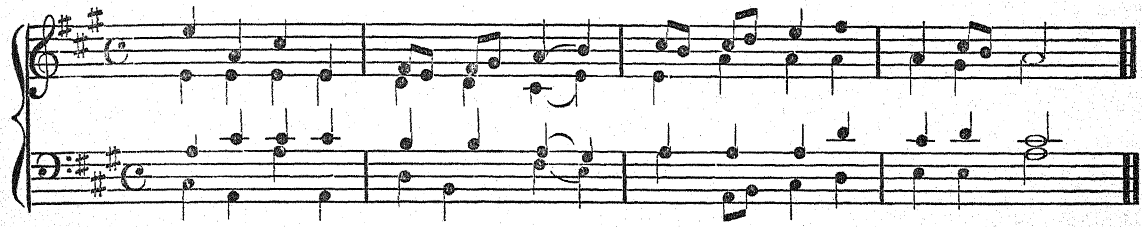
Exercise 80.—CHRISTIAN SOLDIERS.

Key A. JAS. SNEDDON, Mus. Bac.



d :m	s_1 :d	t_1.l_1 :t_1.d	r :—	m :d	s :t_1	d.t_1 :d.r	m :—
s_1 :s_1	s_1 :s_1	s_1 :s_1	s_1 :—	s_1 :s_1	s_1 :f_1	m_1 :s_1	s_1 :—
m :d	m :m	r.d :r.m	t_1 :—	d :m	r :r	d.r :m.t_1	d :—
d :d	d :d	s_1 :s_1	s_1 :—	d_1 :d	t_1 :s_1	l_1 :s_1	d :—

1. Much in sor - row, oft in woe, On - ward, Chris - tians, on - ward go!
2. On - ward, Chris - tians, on - ward go! Join the war and face the foe;



s :d	m :s_1	l_1.s_1 :l_1.t_1	d :r	m.r :m.f	s :l	d :m.r	d :—
s_1 :s_1	s_1 :s_1	f_1 :f_1	m_1 :s_1	s_1 :d	d :d	d :t_1	d :—
d :m	m :m	r :r	d :t_1	d :d	d :f	m :f	m :—
m_1 :d_1	d :d_1	f :r	l_1 :s_1	d :d_1.r_1	m_1 :f_1	s_1 :s_1	d :—

Fight the fight, main - tain the strife, Strength - ened with the bread of life.
Faint not, much doth yet re - main, Drea - ry is the long cam - paign.

DRAWING.—CHAPTER IV.

FOLIAGE AND FLOWERS—SKETCHING FROM NATURE.

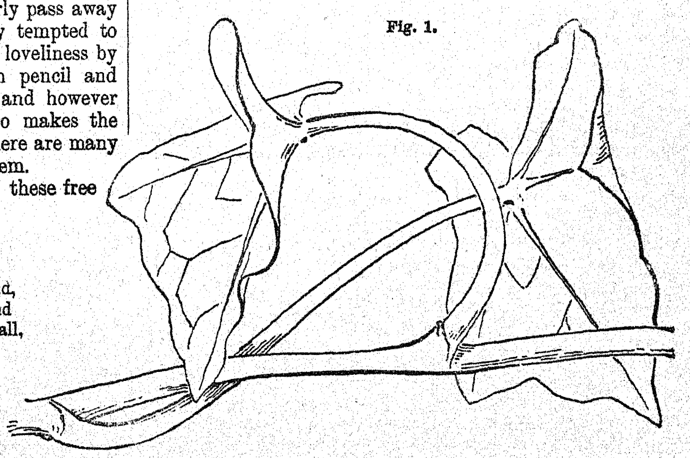
No part of the art-student's work is more attractive, or more generally instructive, than that which leads to the minute study of the forms of nature. Although the love of flowers, and the desire to have and enjoy them, is so universal, it is astonishing how carelessly most people look at them, and how little they really know about them. Their beauty is used for the adornment of the house or the person, and when they fade they are usually, without much thought, cast aside. Still there are some few who regret that all this fascinating beauty of form should so utterly pass away from sight; and some of these few feel sorely tempted to make an effort to perpetuate the charms of this loveliness by imitating their form or colour (or both) with pencil and brush. However slight this attempt may be, and however poor the result it yields, yet the student who makes the effort must gain by setting himself to it, for there are many things to learn *from* flowers as well as *about* them.

Our poet laureate thus thoughtfully writes of these free gifts of nature:—

> "Flower in the crannied wall,
> I pluck you out of the crannies;
> Hold you here, root and all, in my hand,
> Little flower—but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is."

The laureate seems as if he would philosophize about it, and find wisdom by so doing. And yet perhaps a more excellent, and if not indeed the best way, certainly a good way to learn and know more about the "little flower," is to sit down and make as careful a drawing of it as possible. A little elementary knowledge of the very attractive department of botany will help us very much in making this drawing, and the Plates illustrative of leaves in BOTANY, Chapter V., can scarcely fail to benefit the student. The first thing we should know or remember about plants is that *they grow*, and that the laws of their growth must be expressed in our drawing. To find out this law of growth it will be well to take some simple spray of foliage and dissect it, dividing the leaves from the branches, and draw the naked branch first. Take, for example, the branch of oak shown in Plate V. Such a branch can be found in any winter walk, and it forms an excellent elementary study; the *joints* should be very carefully studied, and some of them separately drawn. The way in which every little spray *clasps* on to the parent stem, and the wonderful mechanism of the joint, will be found to be not only so beautiful, but so well adapted to its purpose, that the student will never again draw this "articulation" carelessly.

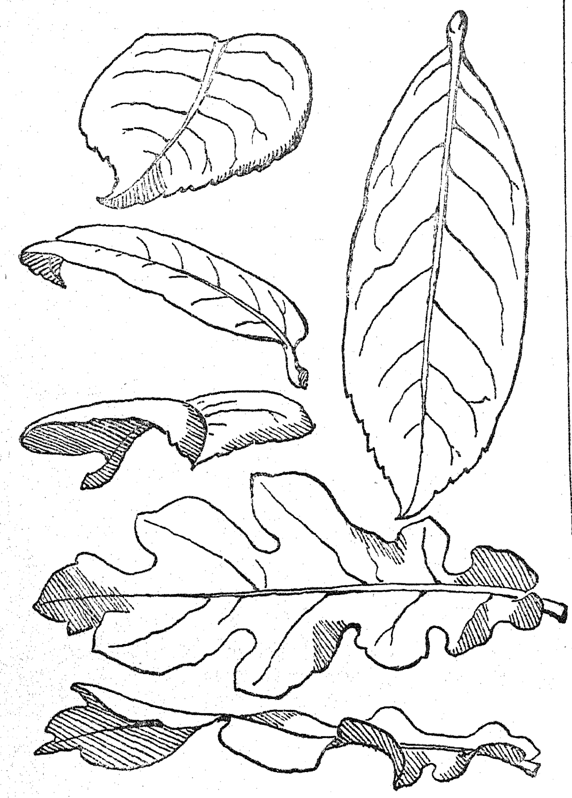
Fig. 1.



Upon examining other plants it will be found that each one—as has been explained in BOTANY—has its own peculiar

way of growing, and that the manner of its growth gives character to the whole plant. A sketch is here given of the ivy, fig. 1, and special attention is called to its branching, and the joints of the leaf-stalks. When the branches have been carefully studied, attention may be given to the leaves. In botany leaves are classified into certain divisions or orders, and these classes have definite names indicative of their characteristics. [See BOTANY, p. 431.] Some examples of these divisions are given in fig. 2, and although these

Fig. 2.



well-defined botanical shapes are often lost in the wonderful and infinite variety of nature, it is well for the student to know that these classes exist, and that the character of each class will be retained in the individual leaf; that is, the "ovate" or egg-shaped leaf will always have a more or less oval form, and the "lanceolate" leaf will always display a lance-head-like form, although on the same plant there may be much variety.

It is also very desirable that the student should know something about the construction of leaves. Every single leaf is made up of two distinct tissues, cellular and vascular. The vascular system includes the veins, the cellular the parts between the veins. The arrangement of the veins in a leaf, or as botanists call it, the "venation," is of great importance to the art-student, for if the veins be put in the wrong direction the leaf at once loses its character. In some plants the venation is unicostate (one-ribbed), or has one main rib with a number of smaller branches, as in the rose; in other plants the arrangement is called multicostate, that is, a number of main ribs or branches start from one point, and then other smaller ones spring out from them. In each of these classes the small veins form a wonderful network (reticulated), becoming finer and finer until the unassisted eye can no longer follow the ramifications. The leaves of another large class of plants are "parallel-veined," that is, the veins start from the base of the leaf, and run in parallel lines to the apex or point, no reticulation or network being formed. This kind of venation is found in all grasses and grass-like leaves, as the lily.

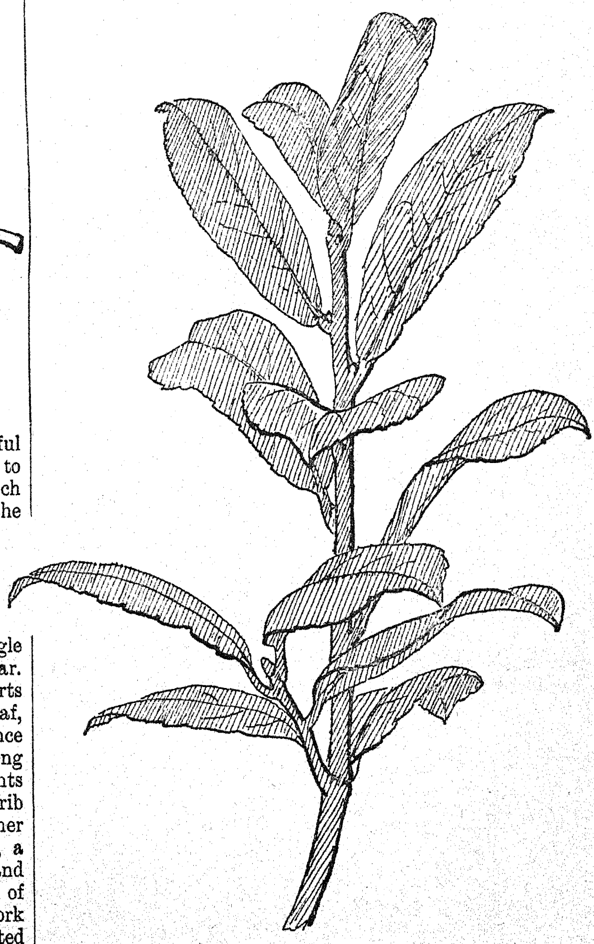
The edges of the leaves should next be studied. Some of these are entire, but many others are divided or indented in a variety of ways; these little divisions are often put in by students with a careless scribble, but much of the character of the leaf really depends upon a careful drawing of the edge. Very many leaves take saw-shaped or serrated edges, some of these being bi-serrated, that is, the little saw-shaped points being again divided, as in the blackberry leaf. Other leaves have dentate edges, that is, scolloped or cut out in little arcs, as the fuchsia, while some are crenate or scolloped in the reverse way to the fuchsia.

The student should now make a practical study of these characteristics by drawing out a number of single leaves in the following manner:—

A leaf having been selected (and a rather large evergreen leaf will be best), it should be pinned up in such a position as to show its whole surface, or as much of it as can be shown without flattening or altering the natural form. In this position the general form, the venation, and the shape of the edge should be carefully imitated; the leaf should then be turned up so as to be seen partly edgewise; and a third drawing should be made when looking as much as possible at the edge of the leaf, as if trying to see how thick it was. Examples of these positions are given in fig. 2.

The study of this single leaf should not be abandoned until it has been drawn in at least half a score of different positions.

Fig. 3.



As in previous exercises, the outline drawings of these leaves may be tinted with one wash of any simple colour—umber or sepia—a careful attempt being made to get the weight, or tone, or value of the leaf as seen against the piece of white paper behind it (see fig. 3).

The next step is to try to put the leaves on the stem — that is, to draw them as they grow. A spray of some ever-

DRAWING.

FLOWERS.

green plant (laurel or ivy), with about six or eight leaves on it, may be taken as the first example. This spray should be fixed in a natural position, that is, vertically or horizontally, just as it was when growing. The stem should be first drawn, its direction being indicated by a single line, and the points where the leaves join on to it should be fixed by a slight mark. It will be well to call attention here to the fact that leaves do not grow at random round a stem, but that each plant has a certain order of growth. Very frequently this regular order is partly lost by the destruction of some of the leaves in the early stages of growth; nevertheless the student should look for order, for in nature order exists, and not disorder. This leaf arrangement having been carefully noted, and the points fixed on the stem, the leaf-stalk and the main rib or centre vein of the leaf should be drawn with one long careful curve. In whatever position the leaf may be placed this one firm curve will be evident, and should be first drawn. The leaf itself should afterwards be drawn round this as a centre line.

The *form* of all leaves should be represented first by a single line; that is, as if the edge were smooth or entire. When the form is accurately drawn then the divisions of the edge and the branching of the veins may be added. It is sometimes a difficulty with students to know how far to carry this matter of veining, and some drawings are covered all over with fine lines in a vain effort to imitate *all* that can be seen. This is an old error in art, and the student ought to learn early, if possible, that the *whole truth* about anything cannot be represented—that it is unwise in drawing even to attempt to do this; and yet that every effort should be made in every stroke of every drawing to represent *the truth*. The veins in a leaf should therefore be drawn with perfect accuracy, so far as the midrib and the primary and secondary offshoots are concerned, unless some special purpose is in view; all else should be omitted.

After having drawn many sprays of various plants the student might again take a very simple group of leaves, and endeavour to imitate the light and shade upon them, using the pencil, the crayon, or the brush.

This will be found to be by far the most difficult exercise yet attempted. The shining surface of some leaves and the hairy surface of others complicate the light and shade; the colour (which we suppose to be omitted for the present) also adds to the difficulty; but by referring to our previous chapter on this subject (p. 470), by choosing a very simple example, placing it in a strong side light, and carefully looking for the shade only, these difficulties, great though they be, may be overcome. It is most important that such difficulties should be grappled with, and, if possible, mastered at this stage, for in the delicate quickly fading forms of flowers, with their brilliant colours, these mysteries of light and shade become harder still to grasp and imitate.

In this article we shall speak only of the *forms* of flowers, not of the colours. We omit this part of our subject with great regret, for the glorious colour of flowers is their chief characteristic, as it is their greatest charm. We hope, however, to lead the student to study and admire the beauty of the form—a beauty second only to that of the colour, yet not quite so easily discovered, and indeed often missed altogether: the shape—the "drawing," as artists call it—being frequently lost, or even unnoticed in the effort made to get the colour.

Again, we shall find that in flowers, as in leaves, there are certain well-defined classes or divisions of form, but in each class almost infinite variety; it is not necessary to describe or even mention here these various classes, as they are dealt with elesewhere. [See Botany, Chap. VI.] But the student should at least learn that all flowers have three distinct parts, the *calyx*, the *corolla*, and the *stamens*; these parts are arranged in wonderfully regular order, and this arrangement should be studied by carefully dissecting a flower, noting its separate parts in position, form, &c., and drawing these various parts in different positions, as shown at fig. 4. When the flower is polypetalous—*i.e.* has many petals—these petals or flower leaves will be found to be arranged with the

Fig. 4

sepals or leaves of the calyx in a regular geometrical order. The four or five petals of the corolla will be found alternated with the same number of sepals, and even the stamens will be seen to be some multiple of four (or five), and to be arranged with perfect regularity in relation to the petals and sepals. Students will find this order and unity frequently diversified by the accidents of growth; but again it is well to know that such order exists, and the student will do well to prove to himself its existence by drawing from nature a series of *geometric* views of the fronts and backs of symmetrical flowers, such as will be found depicted in the Plates illustrating the lessons in Botany. Practice in the drawing of side elevations and even sections of such flowers would help to realize to the mind a better knowledge of their construction.

When a single flower has been patiently studied, not only in various positions, but also in various stages of its growth, from the bud to the full-grown flower, then a group of flowers as they grow on the stem, such as the spray of a lily, shown in Plate V., should be taken.

The student will, on due examination, perceive that in the flower—as in the leaf—there is a regular and characteristic order of growth for each class of plant. This arrangement of the flowers on the axis, called the "inflorescence," should be studied in the chapter devoted to that topic in Botany, and thereafter pursued from an artistic point of view from nature, by making a number of careful sketches of the flower stalks of various plants. Here let us point out, as illustrating the usefulness of drawing, that it is hardly possible to study the science of botany without such a practical skill in and knowledge of drawing as to enable us to make careful and minute sketches of plant-form.

Before commencing to draw the spray of flowers above mentioned, according to the advice given, it will be advisable to arrange and group them carefully in a good light and with a sheet of white paper placed behind them. Every effort should be made to preserve the flowers as long as possible by putting them in water and keeping them in a cool place, as nothing is more disappointing and disheartening to a student than to find that his subject is drooping, fading, or falling to pieces, before his drawing is half finished. Some amount of change is inevitable, for if the flowers do not droop they will grow; but still a fair amount of permanency or stability of

form may be assured by due thought and well-considered care.

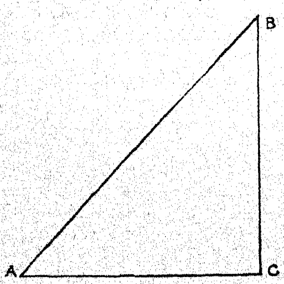
When the student has arrived at such a stage in his progress in reproductive art that he has, by practice, acquired the ability to execute a fairly good drawing of a simple spray of flowers, he will begin to feel that both the floral subjects for his pencil and his delight in the reproduction of their forms are alike infinite.

There is here also afforded him an almost unlimited possibility for improvement; for not only should these drawings be strictly correct, like the drawings from copies and objects, but there may be added to this rigid correctness an amount of delicacy and feeling exhibited in selection, arrangement, combination, and correlation which is only limited by the capacity and opportunity of the student. The more these lovely forms are investigated the greater is the number of beauties they disclose, and the more dexterous is the skill required to depict them truly and feelingly. There is only one step more for the student to take in regard to the pursuit of this delightful branch of our subject. Having studied the flowers in the class-room or in his own home, let him next hie to the home of the flowers, and, taking his pencil and sketch-book into the garden, the fields, or the woodlands, study the flowers as they grow in the glorious profusion of nature. The first difficulty in such study will be to select from the ample store the subject which will be sufficiently simple for the student's capacity. No search need be made for flowers that are brilliant or rare; the very grass of the fields will be found by the seeing eye to be full of lovely and delicate forms, and the simplest flower in a common hedgerow displays charms of form well worthy of all the skill of the most able artist. Let these jewels of the earth be studied thoroughly and patiently with humility, nay even with reverence, and not only will the hand be trained to skilful and delicate delineation, but a new world full of beauty and purity will be opened up to the eye, the mind will be filled with wonder and admiration, and the heart lifted up in thankfulness to the Creator who made this world so wondrous fair, so fairly wonderful.

TRIGONOMETRY.—CHAPTER VI.

TRIGONOMETRICAL CANONS—RATIOS OF ANGULAR MEASURES — FRACTIONAL FORMULÆ — LOGARITHMIC TABLES AND THEIR USES—EXAMPLES.

A TRIGONOMETRICAL canon is a table in which the length of the sine, tangent, secant, &c., to every degree and minute of a quadrant, of which the radius is accepted as unity, is clearly exhibited. Unity is, in most tables, conceived as being divided into ten millions (10,000,000) of decimal parts. Circular arcs cannot be compared one with another or with straight lines by their geometrical properties. In endeavouring to find direct relations between angles and the sides of triangles, we have been led to notice that there are certain ratios involving the length of circular arcs which we can use as the measures of angles. It is difficult, however, to introduce the measures of angles into our calculations, and we find it easier to use, in place of these, certain ratios involving the sides of right-angled triangles only, which are capable of being compared one with another by means of their geometrical properties. These ratios—though their use is now extended into all branches of mathematics and of sciences having a mathematical basis—are designated trigonometrical ratios. They supply the means of representing the value of an angle in the same kind of measure as that in which the sides of a plane triangle are expressed—*i.e.* linear measure.



There are, it is obvious, six fractions which can be formed by the sides of any triangle, taking them together two by two. Of these six fractions it has been found convenient to calculate the numerical values from 0° to 45°—*i.e.* throughout an entire quadrant, and to incorporate them in tables for use in calculation. On examining the preceding figure, it will be seen at once that the following are the six possible fractions, viz.:—

(1) The ratio of (*a*) the side opposite to the angle to (*b*) the hypotenuse, *i.e.* the fraction $\frac{\text{perpendicular}}{\text{hypotenuse}}$, which is the *sine* of the angle.

(2) The ratio of (*a*) the side opposite to the angle to (*b*) the side adjacent to the angle, *i.e.* the fraction $\frac{\text{perpendicular}}{\text{base}}$ which is the *tangent* of the angle.

(3) The ratio of the hypotenuse to the side adjacent to the angle, *i.e.* the fraction $\frac{\text{hypotenuse}}{\text{base}}$, which is the *secant* of the angle.

(4) The ratio of (*a*) the hypotenuse to (*b*) the side opposite to the angle, *i.e.* the fraction $\frac{\text{hypotenuse}}{\text{perpendicular}}$, which is the *cosecant* of the angle.

(5) The ratio of (*a*) the side adjacent to the angle to (*b*) the side opposite to the angle, *i.e.* the fraction $\frac{\text{base}}{\text{perpendicular}}$, which is the *cotangent* of the angle.

(6) The ratio of (*a*) the side adjacent to the angle to (*b*) the hypotenuse, *i.e.* the fraction $\frac{\text{base}}{\text{hypotenuse}}$, which is the *cosine* of the angle.

These may be arranged in the undergiven formula:—

$\frac{BC}{AB}$ with its reciprocal $\frac{AB}{BC}$. The former of which is the *sine* of the angle A or sin A; the latter the *cosecant* of the angle A or cosec A.

$\frac{BC}{AC}$ with its reciprocal $\frac{AC}{BC}$. The former of which is the *tangent* of the angle A or tan A; the latter the *cotangent* of the angle A or cot A.

$\frac{AB}{AC}$ with its reciprocal $\frac{AC}{AB}$. The former of which is the *secant* of the angle A or sec A; the latter the *cosine* of the angle A or cos A.

This may even take the following form of expression:—

$$\sin A = \frac{1}{\text{cosec } A}\,;\ \text{cosec } A = \frac{1}{\sin A}\,;$$
$$\tan A = \frac{1}{\cot A}\,;\ \cot A = \frac{1}{\tan A}\,;$$
$$\sec A = \frac{1}{\cos A}\,;\ \cos A = \frac{1}{\sec A}\,;$$

which has the advantage of enabling us frequently to reduce the expression from a *fractional* to an *integral* form.

Of these trigonometrical ratios the sine, cosine, and tangent are, in practice, the most frequently employed, and they may therefore be called the *primary* ratios. The secant, cotangent, and cosecant may be considered as *secondary* ratios, while the versine ($=1-\cos A$), and the su-versine ($=1+\cos A$) may be regarded as *tertiary* ones. As we have seen that the trigonometrical ratios determine the angles, and conversely the angles determine the ratios, it follows that any determinate value which may be given to the one enables us to find a determinate value for the other.

Only a word of caution may be required here—viz. that though for the same angle there is one determinate value, and one only, for each of its trigonometrical ratios, the converse does not hold, that for any given value of the sine, tangent, cosine, &c., there is one determinate value, and one only, of the angle. This requires to be kept in mind to prevent mistakes, for there are (possibly) corresponding to the same value of the sine, tangent, cosine, &c., an indefinite number of values of the angle.

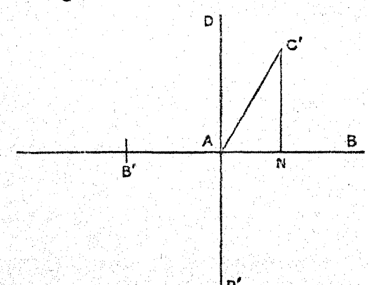
The values of the trigonometrical ratios of all angles in a quadrant, *i.e.* from 0° to 45°, have been (as we have said)

calculated and reduced to a tabular form, which is given in mathematical treatises compiled for the purpose as a "Table of Natural Sines," &c. This table, however, is not now so much used as it was formerly. It has been found to be far more convenient to make use of the *logarithms* of the natural sines, &c. These logarithms are found in another set of tables (now in very general use), entitled "Table of Logarithmic Sines, Tangents," &c., in which the values of the trigonometrical ratios are registered side by side with the angles to which they correspond. Cagnoli thinks that the best way of *computing* trigonometrical tables is first to form the table of natural sines, and then to take from the common tables of logarithms the logarithms of the numbers therein given. Tables have been so thoroughly verified, that in most cases they are accepted as certain, and computation is now very seldom made. It has been shown that when the sines and cosines of any angle are known, the tangents and secants are readily found, and tables of tangents and secants are also in reality tables of cotangents and cosecants.

It is a fact that all rectilinear figures can be divided into triangles, and every triangle is either (1) right-angled, (2) the sum of two right angles, or (3) the difference between them. Thus, in reality, the knowledge attained, through trigonometry, of triangles alone, can readily be transferred to and become an aid in the computation of the proportions of figures of any sort. If therefore tables are formed, which present in an easily applicable arrangement the proportionate values of the sines, cosines, and tangents of all angles, they would, really, not only register the proportions of every right-angled triangle, but also the proportionate measurements of all surfaces. For, as we have shown above, the secant, cosecant, and cotangent of any angle are the reciprocals respectively of its sine, cosine, and tangent; and this fact may be put in tabular form thus:—

1. The sine of an angle $=$ (*a*) the cosine of its complement. (*b*) the sine of its supplement.
2. " cosine " $=$ (*a*) the sine of its complement. (*b*) the cosine of its supplement.
3. " tangent " $=$ (*a*) the cotangent of its complement. (*b*) the tangent of its supplement.
4. " secant " $=$ (*a*) the cosecant of its complement. (*b*) the secant of its supplement.

The annexed figure will enable the student to familiarize



himself with and to verify these various [and all their concurrent and consequent] relations.

Trigonometrical formulæ are translated, as it were, into numerical values by *logarithms*. The word logarithms is compounded of two Greek words, *logos*, used with the signification of ratio, and *arithmos*, meaning number; and it is therefore literally a term signifying the ratios of numbers. These logarithms are artificial numbers employed to abridge the operations of computation, and the logarithm of a number is the exponent of the power to which some other given invariable number must be raised so as to produce the original number. The invariable number is called the base. It may be either greater or less than unity, but when once chosen and fixed upon it must be retained in the formation of all numbers in the same system of tables.

It has been found that a system of logarithms calculated on the base 10 is far more convenient and workable than any other, and hence almost all the tables of logarithms now in common use are computed on that base, and this is generally known as Briggs' system. In these logarithms (*a*) the integral portion is called the *characteristic*, and (*b*) the decimal part is called the *mantissa*—from a word of Tuscan origin signifying a make-weight, an overplus, a handful thrown in over and above the precise weight. Hence with a base of 10 it is only necessary to register the *mantissa* in the tables, as we can determine the *characteristic* by counting the digits in the integral portion of the number of which the logarithm is sought.

If we have, for example, 73594 given as the original number of which we are to find the logarithm, we see that it lies between 10,000 and 100,000, or in another form of expressing the same fact, 10^4, *i.e.* 10 raised to the fourth power, and 10^5, *i.e.* 10 raised to the fifth power; and it must therefore have for its characteristic, *i.e.* the integral part of its logarithm, 4 with a mantissa, *i.e.* a decimal annexed to it. In the case of the number before us, it would take the following tabular form according as it was required, as of the first, second, third, fourth, or fifth, &c., power:—

In the first instance ·73594 being taken as only a decimal part of, and therefore as less than unity, receives the negative sign; it is, however, more common and convenient to use, instead of the negative sign, the characteristic of the arithmetical complement, as

Log	·73594	$=\bar{1}$·8668424
	7·3594	$=0$·8668424
	73·594	$=1$·8668424
	735·94	$=2$·8668424
	7359·4	$=3$·8668424
	73594·	$=4$·8668424

·73594 = 9·8668424, &c.

From this example we may see the immense advantage of logarithmic tables. The same register in the tables can be made to serve for any series of numbers which have the same significant digits occurring in the same succession, and differ only in the position which the unit's place has among these digits; as, the logarithm of the number 3·4567, which is ·5386617, can be employed to express the logarithm of any one of a whole series of numbers, such as 345670, 34567, 3456·7, 345·67, 34·567, 3·4567, ·34567, ·034567, &c., inclusive of any number formed (1) by adding cyphers to the end of the integral series, or (2) by adding cyphers to the beginning of the decimal series. All the whole numbers from unity [1] up to a certain (indicated) limit—say 100,000—with their logarithms (in which, however, the characteristic is usually suppressed) are contained and exhibited in tables of logarithms. They thus contain all numbers consisting of not more than five digits, and are generally computed to seven places of decimals. It is a well-known fact that an alteration of the decimal point is equivalent to a multiplication or a division (as the case may be) by some entire power of 10, *i.e.* alters the logarithm by a whole number either added or subtracted. Hence the fraction less than unity, which is a part of every logarithm, does not depend on the position of the decimal point, but altogether upon the significant figures. It may be as well to note, here, definitely, that those figures which precede the decimal point are called *integers*, those which follow it decimals, and that figures, as contra-distinguished from ciphers, are denominated significant. Thus in 368·414 the 368 are integers and the 414 decimals. Had it been 36·841400, the 4 preceding the ciphers would be called the last significant figure. From this remarkably simple consideration the following rule is deduced:—*If the number be an integer, the characteristic of its logarithm is the number of digits of which it consists diminished by unity* [1]; *and if part of the number be a decimal, the characteristic is the number of digits to the left of the decimal point diminished by unity* [1]. Considered thus as trustworthy registers of the numerical value of certain ratios already calculated, and therefore capable of being referred to and used without the trouble of fresh computation, logarithmic tables are of great benefit in securing expedition and accuracy. In consulting tables of logarithms, the number of which we seek the logarithm is called the argument, and the logarithm sought is named the function, *i.e.* if the number for which a logarithm is to be found is 90 that is the argument, and we find as its function 1·954243. Con-

versely, if we have the function, *i.e.* the logarithm 2·394452, the number of which it gives the value is 248. In trigonometry again, for instance, if we had an angle 32° 24′, and taking that as argument, looked in the logarithms of tangents, sines, &c., we should find that the tangent was ·6346193 and the sine ·5358268, and these would both be functions of the angle 32° 24′. Suppose, again, that we have given us $6 : 12 :: 50 : x$ to find what x is. We would require to take the logarithm of 12 and add to it the logarithm of 50, and from the sum subtract the logarithm of 6; the calculation would stand thus:—

$$\begin{aligned} \text{Log } 12 &= 1{\cdot}079181 \\ +\ \log 50 &= 1{\cdot}698970 \\ \hline & \ \ 2{\cdot}778151 \\ -\ \log\ \ 6 &= 0{\cdot}778151 \\ \hline \therefore \log\ \ x &= 2{\cdot}000000\ \ i.e.\ x = 100. \end{aligned}$$

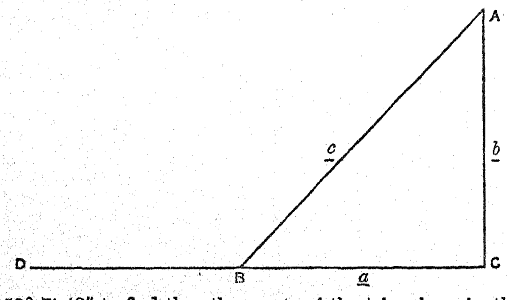
To find numerical value of x if $a=20$ and angle $A=30°\,10'$. Having given that $\frac{x}{a} = \cot A$, we require to proceed thus: as $\frac{x}{a} = \cot A \mathrel{.\,\cdot.} x = a \cot A$, so that, in tabular logarithms, $\log x$ will equal $\log a + \log \cot A - 10$.

Knowing that $a=20$, we "enter" the table of the logarithms of numbers with 20 as argument, and find its log $=1{\cdot}301030$; and angle A being 30° 10′, we find on looking in the table of 30° opposite to 10′ in the number of minutes given down the left side, and in the column headed by the word "cotangent," that its $\log = 10{\cdot}235648$. These we place as before, thus:—

$$\begin{array}{lll} a = 20 & \log a & = 1{\cdot}301030 \\ A = 30°\ 10' & +\ \log \cot A & = 10{\cdot}235648 \\ \hline & & \ \ 11{\cdot}536678 \\ \text{from which we subtract} & \log \text{rad} & = 10{\cdot}000000 \\ \hline \text{which leaves us} & \log x & = 1{\cdot}536678,\ i.e.\ x = 34{\cdot}41, \end{array}$$

as we discover by observing the method explained for taking out the figures in the introductory part of the tables employed.

Again, if in a rectangular triangle A B C, there is given the side B C equal to 162 yards, and the acute angle B equal



to 53° 7′ 48″ to find the other parts of the triangle—viz. the angle A and the sides A C and A B, we proceed thus:—Angle $C=90°$, and angles $A+B=90°$, therefore angle A equals $90° - 53°\ 7'\ 48''$, *i.e.* 36° 52′ 12″. Then to construct the triangle let us (1) from the point C, draw the indefinite line C D, and (2) at the point B, in the line C B, made from a scale of equal parts equivalent in ratio to 162 yards, lay off the quantity of the angle B, viz. 53° 7′ 48″. Upon the line B C erect a perpendicular at C, meeting A B in A, and of course making the angle $A=36°\ 52'\ 12''$.

We may indicate the lines B C by a, A C by b, and A B by c, and can reason in this way: Log A C = log B C + log tan B − log rad, therefore the computation stands thus:—The log A C = the log B C, which is 2·209515 (as we find at once on inspecting the table of logarithms under the number 162) + log tan B, *i.e.* 53° 7′ 48″—which we find by turning to the logarithmic tables of sines, tangents, &c., at the bottom of the page (because the angle is above 45°), and looking up the column of tangents, guiding ourselves by the minute figures on the right hand up to 7—to be 10·124727. Besides which we have, on the left hand, the difference ·438″ given, this we require to multiply by the 48″ and get for answer 21024, from which, on cutting off two decimal places, we have 210 to add to the original logarithm, *i.e.*

$$10{\cdot}124727 + 210 = 10{\cdot}124937.$$

These we are now prepared to arrange in working order:—

$$\begin{array}{rll} (1)\ \text{Log } AC = \log BC & = & 2{\cdot}209515 \\ +\log \tan B & = & 10{\cdot}124937 = \\ \hline & & 12{\cdot}334452 \\ -\log \text{rad} & & 10{\cdot}000000 = \\ \hline & & 2{\cdot}334452 = \end{array}$$

log 216 yds., length of side A C;

$$\begin{array}{rll} (2)\ \text{Log } AB = \log BC & = & 2{\cdot}209515 \\ +\log \sec B & = & 10{\cdot}221848 = \\ \hline & & 12{\cdot}431363 \\ -\log \text{rad} & & 10{\cdot}000000 \\ \hline & & 2{\cdot}431363 = \end{array}$$

log 270 yds., length of side A B.

Ans. Angle 36° 52′ 12″
Sides, A C 216 yds., and A B 270.

These are the chief explanations required for the working out of trigonometrical questions by the use of logarithmic tables, so far as regards those concerned with right-angled triangles. The management of obtuse-angled triangles we shall deal with in our next chapter.

HISTORY OF GREAT BRITAIN AND IRELAND.

CHAPTER V.

THE NORMAN MONARCHS—WILLIAM RUFUS—HENRY BEAUCLERK—STEPHEN OF BLOIS.

William Rufus was on his way to England while his father was dying. On his arrival he assembled the Norman barons, and told them his father had nominated him successor to the throne. Many of them had large possessions in both countries, and were anxious that Normandy and England should be held by the same sovereign. Lanfranc espoused William's cause, and he was crowned 26th September, 1087. Robert's claims were thus ignored; but a conspiracy in his favour, headed by Odo, bishop of Bayeux, Roger, earl of Shrewsbury, and others, was formed. They raised troops and threatened to depose William II. He, on his part, promised the Saxons good government and a relaxation of the severe rule under which they had hitherto been held. By their aid Odo was driven from the kingdom, and subsequently died as a beggar in Palermo. A revolution was next attempted in Normandy to depose Robert and put William in possession of the sovereignty of Maine, Normandy, and England. William invaded his brother's territories, gained many strong places, but was foiled at Rouen. Through the intervention of the French king, Philip I., this quarrel was brought to a peaceable close, Robert agreeing to mortgage Normandy to William for 10,000 marks, with which money he resolved to betake himself to the military enterprise for the recovery of the Holy Land from the Saracens, then originated by Peter the Hermit, under the name of a crusade.

Einion, son of the Lord of Dyved (Pembroke), who had served in the Norman army, sought the aid of Robert Fitzhamon and some other knights in favour of Jestyn, lord of Glamorgan, against Rhys ap Tudor, who was slain. The Normans afterwards drove Jestyn from Dynevor and established themselves in the Honour of Glamorgan. They built eighteen castles in it, and divided it into the fees of thirty-six knights. They bestowed the interior on Einion. Thereafter William granted lands in Wales to such knights as chose to conquer any part of it. Brecknock was subdued by Bernard Newmarch; Henry Newburgh, earl of Warwick, made himself master of Gower; Montgomery (then called Baldwin's Castle) was taken by Roger of Shrewsbury; and Hugh, earl of Chester, ravaged the north-west coast and took possession of Anglesea.

Edgar Atheling, having been deprived of some estates in Normandy at William's suggestion, sought help for their recovery from Malcolm Canmore of Scotland. Malcolm laid claim to the counties of Cumberland and Northumberland, and William denied his right to them. Malcolm invaded England, was opposed by Sir Roger de Mowbray, by whom he and his son were decoyed into an ambush and slain. Queen Margaret, the wife and mother, on hearing of their death, gave up the ghost. She had done much to benefit Scotland by her genius, piety, and general good sense. Donald Bain, Malcolm's brother, was chosen king, and expelled the English and Normans from Scotland; but Duncan, an illegitimate son of Malcolm, on doing homage to William, gained his help and for a time acquired dominion in Scotland, though it did not prove of long duration. Donald Bain, in 1094, reasserted his right to the throne. Edgar Atheling ultimately succeeded in establishing his nephew Edgar as sovereign of Scotland.

William was of middle height, large-limbed, and very stout. His eyes were gray spotted, keen, and restless. His brow was high, bossed, and broad. His voice was boisterous, though when he was angry he stammered. His hair was of ruddy auburn hue, and his face red (on this account he was named William Rufus or the Red). He was passionate and foul of speech. Though he was the kindliest of William's sons, brave as a man and good as a master, he was fierce, tyrannical, and a promise-breaker. He was rich, proud, and powerful—really the greatest king in Europe.

Lanfranc had died 24th May, 1089, and during four years William kept the see vacant. Then he appointed Anselm, a native of Aosta in Italy, who had taken the monastic habit at Bec in Normandy, under Lanfranc. Anselm stipulated that the possessions of the see should be restored. William after much hesitation assented, and the consecration took place 5th December, 1093. Anselm proposed to proceed to Rome to receive the *pallium*, or sacred mantle of investiture, from the Pope. William resisted, Anselm persisted. Upon this they quarrelled, and as soon as the prelate left the country the king seized the archbishopric and annulled all Anselm's administrative acts. The primate, who was a theologian, a scholar, and a philosopher of no mean reputation, was received honourably by the Pope.

The mortgage-money which William had advanced to Robert was to have been repaid in five years by the Normans. As it was not paid, William resolved on foreclosing the mortgage, invaded and overran Maine and Normandy, so that while Robert was marching to besiege Jerusalem and drive from it the Saracenic foe, William was claiming military mastery over the Vexin territory, and grasping the rod of empire over Robert's realm.

William, like the Conqueror, was fond of hunting, and though the establishment of the New Forest, in the south-west of Hants, as a great hunting-ground was a highly unpopular act of William I., Rufus held it ruthlessly against all malcontents. On 1st August, 1100, the king was in Malwood Keep. Revelry was running rather riotously, and William Rufus was rejoicing in the season of sport on which he was about to enter. Evil dreams and omens of ill were quoted to him. He was dispirited at dinner, but strove to rouse his relaxing energy by large draughts of wine. His merriment rose to boisterousness, and, afternoon though it was, he would to the chase. Before setting out, he presented two of his best arrows to Walter Tyrrell, saying, "sharp shafts for the surest marksman." When the driving of the deer began, Rufus and Tyrrell alighted. They were posted near each other in a ride alone. The sun was setting. The king was shading his eyes from the glare of the level light. A great grizzled hart came bounding on. Rufus shot and missed. "Shoot, Tyrrell, shoot, in the devil's name," he cried. Tyrrell obeyed; his arrow grazed the quarry, but, glancing off its hide, it pierced the heart of the king under his yet upraised arm, and he fell. Tyrrell saw Rufus fall and fled. The body lay there till the day closed. It was then taken in a charcoal-burner's cart, as if it had been the carcase of a boar, to Winchester, where by the soldiery and his boon companions it was committed, without ceremonial, to the ground. Henry, who had been riding near the place, so soon as he knew that his brother was really dead, galloped off at full speed, and with unslackened bridle, after a twenty miles' ride, reached Winchester and rushed to the treasury. William de Breteuil, the treasurer of Rufus, who, guessing his purpose, had ridden pace for pace, opposed his seizure of the wealth, claiming it as Robert's. Henry, drawing his sword and threatening instant chastisement, succeeded in making himself master of the regalia and the royal moneys. The possession of these made his course easy. Henry was crowned king at Westminster on Sunday, 5th August. Knowing his claim was weak, he conciliated all parties by fair promises, and so strengthened his position by a free use of the treasures of which he had so hurriedly acquired possession, that, before Robert could return from Palestine, the service of many willing Saxon swords had been won over to his sovereignty. The ruthless, cruel, extortionate, and overbearing rule of William II. made English and Norman alike welcome one to the throne whose weakness of claim made their help requisite and their allegiance valuable.

Henry I., surnamed *Beauclerk*, the youngest son of the Norman invader, was born at Selby, in Yorkshire, 1068—two years after the Conquest. He had led a life of strange vicissitudes, and had learned by experience to be politic, and how to manage men. He imprisoned Ralph Flambard, and thus conciliated at once the church and the taxpayers, entreated Anslem to return to England, and married, as a representative of the old Saxon line, Edith, daughter of Malcolm and Margaret of Scotland—greatly to the delight of his English subjects. Edith on her marriage took, in honour of Henry's mother, the name of Matilda, and Henry granted a charter in which he undertook to lay no claim to unreasonable benevolences, wardships, or other oppressive feudal burdens. By these means the handsome, scholarly sovereign secured popularity, and wrought into national unity of feeling Saxon and Norman. When, therefore, his eldest brother Robert, returned crownless from the Crusades, found Henry holding the sceptre which his father had won, he was inclined to fight for his rights, and some of the Norman barons encouraged him in putting his claims to the test of battle. Robert did land in England, but Henry, aware of Robert's careless indolence of character, politicly proposed to pay him an annuity of 3000 marks, on condition of relinquishing his claims, and that upon the decease of either of them, the other should succeed to the dominions he held. After a stay of two months in England Robert returned to Normandy, having arranged with Henry that no harm should befall his Norman sympathizers now that they were friends again. Henry, however—resolved to punish Robert of Belesme, the crafty Earl of Shrewsbury—led an army against him, defeated him, confiscated his estates, and drove him and his followers into exile. Anselm also left England because Henry would not concede his demands regarding investiture and homage. Robert received these malcontents and so excited his brother's anger. In a short time Henry contrived a cause of war, and entered Normandy with a hostile force.

Robert had relapsed into self-indulgence, and left his duchy very much to the management of favourites, who practised many extortions upon the people. These, knowing Henry's aim, sent an embassy requesting his aid for the repeal of their grievances. Henry's ear was open at once to the petitioners. He proclaimed his design of becoming their protector, and transferred his large army to Mortaigne. Then, after an unsatisfactory conference held at Caen, the forces of the two brothers met at Tenchebrai, on 28th September, 1105, the anniversary of their father's landing at Hastings forty years before. The field of fight was so thronged with phalanxed forces that little or no real injury was done to the troops of either side. Boudri, one of the chaplains of Henry, took Duke Robert prisoner; Edgar Atheling and many of the refugee nobles were captured. The conflict ceased, and Henry annexed Normandy again to England. Atheling, as the queen's uncle, was set free and treated rather as an object of pity than of fear; but the deposed Duke Robert was confined in Cardiff Castle, whence he only found escape at the age of eighty, through the narrow gateway of death, in 1135. William of Mortaigne died early in durance, and his earldom was conferred on Henry's nephew, Stephen of Blois. Anselm and Henry arranged that the staff and the ring should be presented to the bishops of the church, and that each new

bishop should do homage for his lands prior to consecration, and swear fealty thereafter. For a short time the land had rest.

But Louis, king of France, having espoused the cause of the young Duke (afterwards of Flanders)—Robert's son William, by Sybilla of Conversona—was regarded by Henry as an enemy. Henry having strengthened himself by getting Matilda, daughter of Fulke, earl of Anjou, as wife to his son William, and his own daughter Matilda married to Henry V., emperor of the West—averted the war which Louis threatened, when the prince had grown up, by the peace of Gisors, 1113. This peace was, however, soon broken, and open war began between France and Normandy, which was brought to a termination by the variously designated battle of Noyou, Brinneville, or Brèmule, on the main route between Rouen and Paris, at which Henry and Louis met, and the latter, being defeated, fled.

Henry, whose wife Matilda had died at Westminster in 1118, established his son William the Atheling as Duke of Normandy, and peace having been procured by the intervention of the Pope between Louis and Henry, the Atheling did homage to Louis for his Norman fief. On 25th November, 1120, Henry and his son were prepared to re-embark at Barfleur for England. There a seaman, whose father had owned the ship in which the Conqueror had sailed, asked the king to make use of his vessel—the White Ship. The king's barque was already chosen, but Prince William, who was rather wanton and boisterous, promised to go in the White Ship and carry in it the royal treasures. Henry set sail in the first watch, and arrived in England safe and well; but the prince, who had given the sailors largess, which they spent in wine, did not start till nightfall. The sea was calm, the wind fair, when the priests came to the water-edge to bless the vessel on its voyage. The seamen, overladen with liquor, hailed them with abuse and set off full of glee. No watch was set, the revelry went on, the mirth of the prince and his suite grew into uproar, and the helmsman got engrossed in the frolic of the carouse. The rowers, stimulated by wine, pulled vigorously. Already they had made five miles of sea-journey, when the ship struck, and staved in its starboard bow, on the reef of Catteville. Horror took hold of the revellers. A boat was lowered. The prince, with as many as the boat could hold, jumped in and rowed off clear from the wreck. Just then William learned that his sister, the Countess of Perche, was not in the boat with him, and insisted that they should row back and rescue her. The boat was swamped, the wreck sank; three only were left alive. Thomas, the captain, threw himself into the sea in despair; a young nobleman, benumbed with the cold, was washed away; and a poor butcher, Berold of Rouen, alone of all that company, saved by some fishermen in the dawn of the next morning, survived to tell the tale. On hearing the news the king fainted; he never, it is said, smiled again, and never mentioned his son's name. Much of the royal treasure was regained, but few of the bodies were recovered.

Henry married in 1121 Adelicia of Louvain, one of Charlemagne's descendants. The king had now no legitimate heir, although he had many children. By his second marriage there was no issue, and therefore the next heir-male and claimant was Robert's son, William. He was handsome and young, and he had the pathos of a romantic life to excite interest. Round this brave, courteous, pious, but unfortunate scion of the Conqueror's race many Norman nobles rallied; but Henry, by a skilfully sudden attack, got most of them into his power in 1124, and William, accepting the duchy of Flanders, desisted, for the present, from pressing his claims. In Flanders he met with opposition to his rule, most probably prompted by his uncle, and while engaged in besieging the Earl of Alsace in Alost (1127) received a wound, from which, shortly after being removed to St. Omer, he died. Prior to his demise he wrote beseeching Henry to take into favour his faithful followers; but though some submitted to Henry most of them joined the Crusaders.

Meanwhile, Matilda's husband, Henry V., the last of the Franconian emperors of Germany, died at Utrecht, 22nd May, 1125, and she returned to her father's house. Henry again arranged a politic marriage for her, securing to her for a husband Geoffrey Plantagenet, earl of Anjou, who was, though unpopular, powerful. Having on Christmas (1126), at Windsor, convened an assembly of nobles, among whom were Stephen, through Adela, the grandson of the Conqueror, David, king of Scotland, Matilda's uncle, and Robert of Gloucester, the king's illegitimate son, Henry enforced their taking an oath that, failing any legitimate male issue of his own, the ex-empress should be heir to the throne and be supported by them as queen. At Whitsuntide (1127), when her marriage was solemnized at Rouen, he claimed a renewal of this oath, and when, in 1133, Matilda bore a son, the glad king rejoiced that the succession was settled. The death of Prince William in 1127 had calmed all fear.

Henry had subdued the greater part of South Wales, and colonized a large part of it with Flemings. North Wales was still stubbornly unsubmissive. He had planned an expedition against them for the spring-time, and gone over (25th November, 1135) to the Castle of Lions, a few miles from Rouen, for some relaxation in his favourite hunting-grounds there. He gave orders for the chase next day. On the morrow he was ill, and having feasted that day on a dish of lamprey-pie, of which he was inordinately fond, his sickness developed into a fever, to which, in the space of four days, he succumbed, in the thirty-sixth year of his reign and sixty-seventh of his age. His rapidly decaying body was sewn up in a bull's hide, carried to Rouen, and thence to St. Stephen's Minster at Caen, whence, after being retained for some time, it was removed to England and buried in Reading Abbey, Berks, which had been founded by him ten years previously.

Henry I. died 1st December, 1135. He was as yet unburied when Stephen of Blois, count of Boulogne, who commanded the shortest sea-route to England, hastened to Dover and announced himself to the men of Kent as claimant of the crown. They did not receive him gladly. His coming was likely to cause trouble amidst the complication which beset the succession. Undauntedly he pressed on to London. There Stephen found more sympathy and less sullenness, though there was little display of zeal. To Winchester he hied and secured the regal crown and the royal treasure—his shrewd and politic brother, Bishop Henry, using his great influence to gain favour for him in preference to his cousin. Matilda was foreign-born, and both as empress of Henry V. of Germany, and countess of Geoffrey of Anjou, had acquired foreign interests and habits; besides she was a woman, and as England's queen might favour too much the politic schemes of her husband, the lord of the Angevins, who had been long at war with the Normans. Robert, earl of Gloucester, was of illegitimate descent, and though very powerful was misliked. Adela's eldest son, Theobald of Champagne, though held in favour by the Normans, had little influence in England, and was unwilling or afraid to dispute his brother's title to the throne. So Stephen's hurried dash secured success, and at Winchester, on the day dedicated to the protomartyr St. Stephen (26th December), the first baron of Normandy became King of England, and based his right thereafter on his being the elect of the people, among whom, during his stay at his uncle's court, he had acquired great popularity.

Stephen was noble in bearing, gracious in manner, urbane and humane. He was adjudged by the Witan to be the most likely to fulfil the functions of sovereignty and to bring to an end the difficulties and dangers which troubled the kingdom. The king and people alike treated with thorough disregard the solemn oaths they had undertaken to acknowledge Matilda as their queen, and recognize the succession as vested in her children; and before the body of Henry I. had been removed from his deathbed, in the Castle of Lions, to its Berkshire burial-place, Stephen had issued a sovereign proclamation promising to the Clergy relief from exactions and freedom of election, to the Barons forest law reforms, and to the Commons exemption from the Danegeld.

David, king of Scots, kept faith with the ex-empress, and declaring in her favour invaded England in February, 1136; but Stephen having met him in Durham, a truce between them was signed, in which David surrendered Newcastle, and Stephen, consenting to David's retaining Carlisle, conferred on his son Henry the earldom of Huntingdon.

On some slight cause of offence Baldwin de Redvers, earl of Devonshire, told Stephen "he was not king of right, and he would no longer obey him." Stephen, aided by mercenaries brought over from Flanders, marched against him and Hugh Bigod, lord of Norwich, who had taken Redvers' part. The king took Norwich and Exeter, but spared his foes. While he was engaged in this civil broil, the Welsh broke their oath of allegiance and plundered the rich lands of England. This revolt Stephen subdued, and spent the next year mainly in securing his power in Normandy, which was threatened by Geoffrey and Matilda. By lavish expenditure he acquired many alliances in France. About Christmas, 1137, rumours of war reached Stephen from Scotland, and whispers of rebellion deepened into threatenings. He crushed the latter rapidly, taking castle after castle with hot aggressive energy. While Stephen was thus engaged in the south, David made repeated incursions into the north. Having agreed with Matilda and Gloucester, who had instigated the barons' insurrection, David crossed the Tweed in March, 1138, and overran the country to the Tees. Stephen, unable himself to head hostilities, intrusted the defence of the north to Thurstan, archbishop of York, who organized an army in haste, and, as he was himself aged and infirm, placed it under the charge of Ranulf, bishop of Durham. The lay nobles of the north led each his own men, and the troops pitched their tents on Cowton Moor, half-way between Durham and York, and near Northallerton. They had with them the banners of St. Cuthbert of Durham, St. Peter of York, St. John of Beverley, and St. Wilfrid of Ripon. These they set on a car in the midst of the field, and grouped around it the levies of the northern shires, the bravest men of York, and the yeomen, foresters, and peasantry of Nottingham and Lincoln, flanked by mail-clad Norman nobles. David's forces, preceded by a lance wreathed round with sprigs of heather for a standard, marched manfully to battle. Prince Henry commanded the lowlanders of the Scottish and the troopers of the English borders; the Islesmen and the Highland clans came next, and under the king a strong body of knights, along with the men of Moray, brought up the rear. A dense fog hid their advance; but when their steady tramp betokened their approach, the Bishop of Durham invoked heaven's aid, and urged Normen and Englishmen to fight hardily. The clansmen, shouting "Albion! Albion!" burst in among the foe and broke their ranks as if they had been spiders' webs. The Normans rallied round the standard, and while the Scots were intent on cutting down the mailed men, the English bowmen hemmed them in and poured upon them a shower of yard-long arrows. The prince had almost reached the standards; but his followers turned upon their aggressors, and in doing so got confused, hesitated, and then fell into disorder. The king interposed. He checked the Normans, and covered the retreat of his own scattered men. On that fatal day, 22nd August, 1138, 12,000 Scots were left upon the field. The English, though they saved their standards, could not follow up their advantage. Three days thereafter David rallied his army at Carlisle, and proceeding to Wark Castle besieged it. It succumbed to famine. On the intercession of Stephen's wife Maud, and Alberic the papal legate, David, at Durham, agreed to a treaty of peace.

Stephen might now have made his throne stable by statesmanship, but his exchequer was exhausted, and he debased the coinage; his great earls had rebelled, and he granted earldoms to new men; his soldiery had fared hard, and he recruited his army with mercenaries; the clergy were wealthy and faithful, but he alienated them. Roger of Salisbury, who had been the justiciar and treasurer of Henry I., and had aided Stephen to seize the sceptre, though old, was influential by wealth, talent, family, and adherents. He had a genius for rearing splendid edifices, and rebuilt the Sarum Cathedral with almost matchless magnificence. He was a castle-builder, and both he and his nephews had fortified their stately mansions and surrounded themselves with military power and pomp. It was suggested to Stephen that these strongholds were preparations for maintaining Matilda's cause. Excited by suspicions the sovereign took advantage of the occurrence of a brawl at Oxford, between the retainers of the Earl of Brittany and the suite of Salisbury, to seize the bishop while at court, and his nephew, Alexander, bishop of Lincoln, in his town lodging. Nigel, bishop of Ely, another nephew, escaped to Devizes. The king besieged him there and ordered his uncle and cousin, who had been incarcerated in separate dungeons, to be kept without food till the Castle of Devizes and the other fortified places of the family were given up. After three days' resistance Ely surrendered. But this roused the clergy, and even his brother Henry, now the Pope's legate, could not brook this sacrilegious handling of the prelacy. He summoned the sovereign to appear before a synod at Winchester. Stephen appeared by proxy, Alberic de Vere pleading for him, and when he found the bishops sternly bent on humiliating the king, the knights who accompanied him being ordered by him to unsheathe their swords, the council was dissolved (29th August, 1139). Within "one little month" the Empress Matilda and Robert of Gloucester were in England, and a civil war began, which lasted fourteen years. Anarchy prevailed. Church and state confronted each other. Matilda held the West, Stephen the East, and the barons engaged in internecine wrong-doings. In 1141 Stephen invested Lincoln, where Robert of Gloucester and Ranulf, earl of Chester, were blockaded by him. On Candlemas, in the battle of Lincoln, the king, after valiant efforts, was defeated, taken prisoner by Gloucester, and sent to Matilda, by whose orders he was cast, chain-laden, into a dungeon in Bristol Castle. At Easter, in a council held at Winchester, the Empress Matilda was chosen as "Lady of the English"—though being already anointed to sovereignty she was not crowned. Before midsummer Matilda was accepted by all—clergy and laity—as their monarch.

The queen, Maud, raised a large army in Kent in favour of her husband, and promptly took the field with them against Matilda the empress. David brought a force from Scotland, and Gloucester led the contingents of the west. The queen attacked these as they were striving to secure Matilda's safe progress to Devizes, and on 14th September captured the Earl of Gloucester and had him conveyed to Rochester. During six weeks negotiations for an exchange of prisoners were carried on, and on Hallowmas the prisoners were set free—Stephen the king, and Robert the earl. The struggle continued. Stephen, having escaped from the shackles that bound him in Bristol, re-assumed the sceptre, and Henry of Winchester, tired of Matilda's self-will, ceased to support the ex-empress, and commanded, on the part of God and the pope, that Stephen—the king by the will of the people and the approval of the supreme pontiff—should be assisted in all that pertained to his sovereign right.

Matilda had thrown herself into the impregnable Castle of Oxford, 1142. Stephen blockaded her. After enduring a three months' siege famine became imminent, but the resourceful Matilda, accompanied by four knights, all like herself clad in white, were let down by ropes in the snow, crossed the frozen Thames, reached Wallingford, and was received by her friends in safety. Then Gloucester engaged in the contest more vigorously and defeated Stephen, who with his brother, the warrior-bishop, fled before him at Wilton. Turmoil prevailed everywhere. The opposing parties fell into fray whenever the slightest chance occurred, and powerful barons made war on one another, like freebooters. After inhuman hostilities and many adventures, the haughty Matilda left England, and Robert of Gloucester dying in 1146, there was no further likelihood of success for the empress's party. Stephen was too weak, however, to subdue his insubordinate nobility, and a new conflict with the church took place.

On the demise of pope Lucius II., Henry of Winchester had been superseded as legate by Theobald of Canterbury, who was the ally of Bigod, lord of Norwich. Theobald excommunicated Stephen, and though by submission the king became reconciled to the church, the legate refused to recognize Eustace of Boulogne, the king's only son, as his successor in the sovereignty—because the holy see regarded him as a usurper.

Prince Henry of Normandy—who had spent his youth in the court of Scotland, been trained under his uncle, David

I., and was knighted by him in the city of Carlisle, 1149—had by the death of his father become possessed of the Duchy of Anjou, and publicly proclaimed himself in succession to his grandfather Duke of Normandy and Maine. He also, by his marriage with Eleanor, the divorced wife of Louis VII., the only daughter and heiress of the Duke of Aquitaine (Gascony), greatly enhanced his territorial power. Then thinking that he might win, were luck favourable, all that his mother Matilda could claim—if not more—Henry landed in England in 1152, with the design of ejecting Stephen from the seat of sovereignty. Stephen raised an army of resistance, and the two kings approached each other in hostile array near Wallingford. A pitched battle seemed inevitable; but owing to the death (10th August, 1153), of Eustace, Stephen's son, against whom he had often defended himself in war, Henry concluded a treaty in which it was covenanted that Stephen should wear the crown during his lifetime and Henry should be his successor. He, as justiciar, remained in England for some time to see that the courts, the old laws, and the coinage of former days were restored, all unlicensed castles destroyed, evil-doers punished, hired soldiery sent off the soil of England, and peace renewed. During this period Stephen and Henry lived in amity, and parting with professions of the most sincere respect, Prince Henry returned to his continental possessions.

Stephen did not long survive the pacification or enjoy the tranquillity of the kingdom. He died at Dover, 24th October, 1154, aged fifty, after a (nominal) reign of rather more than eighteen years. He was buried in the Abbey of Feversham, which he had built and endowed, and where he had laid his wife Maud three years previously, and his rash and passionate son Eustace scarcely a year before. Tall, handsome, gracious, he was personally popular, though rather unfitted for rule. His surviving son William was by treaty secured in all the possessions, English and foreign, of which his father stood seised prior to his acquisition of the English throne. He died without issue in 1160.

THE GREEK LANGUAGE.—CHAPTER V.

GREEK VERBS—THE FORMATION OF TENSES—CONJUGATION—TABLES OF PRINCIPAL PARTS—EXERCISES.

In the Greek language the verb differs considerably in nature and form from its representative in most modern tongues. One single word in Greek may include in itself the whole three elements—subject, copula, and predicate—of a logical proposition; as, ἐγρήγορα, I | am | awake. This arises from the verb being, in reality, a compound word, consisting (1) of an elemental stem, in which the essential idea it conveys is contained, and (2) of differential inflexions, which affect and modify the original simple meaning of the stem. The stem, in which the idea of the verb is actually embodied, is usually short and readily expressed. The modifying prefixes and suffixes which, after satisfying the laws of euphony, give origin to the secondary and other subordinate forms indicative of specific relations between the main idea and other elements of thought, of course coalesced with and became integral parts of the verb, and imparted an idiomatic signification to those interweavings of stem and inflexion. The verb as a complex phraseological term—consisting of a stem and the appendages which modify it—is a part of speech requiring thoughtful study; and the necessity for this careful exercise of thought is increased (1) because of the number of relations—of number and person, tense and mood—which have been incorporated with and made parts of the predicative element in speech; and (2) because, as Dr. A. N. Carmichael has put it, "it is impossible to produce from the widest survey of Hellenic literature, as it has descended to us, an instance of a verb exhibiting in its present usage the entire tenses of a complete conjugation." It is therefore only "by an adaptation of parts proceeding from one variously modified stem, or from different roots of similar or cognate signification, that a form or paradigm has in many cases been evolved in such a way as to give this interesting element of speech all the reality of a perfect system."

As regards persons and numbers, the Greek verb not only accepts the necessary threefold relation of a person or persons (1) speaking, (2) addressed, or (3) spoken about, but it also recognizes the marvellous duality of things in the universe, and makes provision for referring to the frequency with which two (as a pair) act together. An act performed by two is felt by the Greeks to be "not common though several." They adopt, therefore, not only the first persons singular and plural, but they employ also the second and third persons in the threefold forms of singular, dual, and plural. This constitutes a specific difference between Greek and the Latin form of languages.

The tense-system of the Greek—*i.e.* its method of expressing the relations of time—is far more comprehensive than those of the Romance and other modern languages owing their origin to the Latin. In the preciseness of its indication of time, the Greek verb possesses a singular superiority over all others. It not only connotes present time by its peculiar and express present tense, but it also marks out *continuation* of past time up to the present time by a reduplication of the root and the addition of an affix, and *posteriority* of past time by prefixing ε and adding a suffix, and also points out the actual *distance and separation* of past time from the present by a specific prefix. It denotes the future in two forms—a strong and a weak—by adding a special element (perhaps a remnant and remainder of the preposition συν, indicative of conjunction) to the verb. The Greek verb not only, therefore, indicates in a most definite manner (1) the simultaneity, *i.e.* immediate presentness, (2) anteriority, *i.e.* the pastness, and (3) the posteriority or subsequentness of speaking and acting, but also the double though indefinite relation of speech to past action, (1) to the past generally or indeterminately, and (2) to some fixed point in the past. The fact of the action spoken about having taken place prior to the time of speaking, is by the Greeks most accurately marked off into past simultaneity in the imperfect, posteriority in the aorist, and anteriority in the pluperfect. There are completeness and precision in the Greek tenses, in regard to specific varieties of time and action, to which modern conjugations supply no parallel, and there is a corresponding difficulty in acquiring a full and ready knowledge of the tense-forms, because we require to be educated into the accurate perception of the distinctness of the divisions in time, as well as in regard to the forms by which these are indicated. The completeness with which the Greeks exhaust all the possibilities of reality, may be perceived when we consider that an action taking place in present, past, or future time, may be regarded as having a threefold mode of performance, and that, philosophically, there might be nine possible tenses, of which they used seven in the active voice, viz. :—

	1. *Momentary.*	2. *Continuous.*	3. *Complete.*
I. Present,	γράφω, *I write.*	γράφω, *I am writing.*	γέγραφα. *I have (now) written.*
II. Past,	ἔγραψα, *I wrote.*	ἔγραφον. *I was writing.*	ἐγεγράφειν, *I had written.*
III. Future,	γράψω, *I shall write.*	(Not used). *I shall be writing.*	(Not used). *I shall have written.*

The chief tenses of the Greek verb are—(1) the present active, (2) the future active, (3) the first perfect, (4) the perfect passive, as well as (5) the first aorist passive, and (6) the first future passive.

These have been, by grammarians, classed as the leading tenses, because they saw in them a series of progressive intermediate derivatives proceeding according to certain formative laws which they have laid down, both laboriously and rigorously, from one common root, in definite lines and modes of descent. Some scholars maintain that this scheme of derivative conjugation is founded on a false and insufficient analogy, results from an imperfect knowledge of the science of language as developed in the new philology, and that it is,

though generally recognized and practically convenient, not capable of philosophic defence on the principles of a sound etymology. It does, however, so far agree with the results of the most advanced philological research, that it affords a simple, easily understood, and well-arranged paradigm of verbal forms, suitable for committing to memory and forming a concise mnemonic of the order and nature of the species of predication expressible by the verb.

The essential tenses of the verb are six—three *primary* and three *historic*. The primary tenses are (1) present, (2) future, (3) perfect; as, λύω, I loose, I am loosing; λύσω, I shall or will loose. λέλυκα, I have loosed. These each express a simple relation of the *action* denoted by the verb to one or other of the three indispensable modes of regarding time. They enable us to state, at once, to which particular portion of time we refer, and to point out a time fixed as contemporaneous with the act of speaking, a time previous, and a time subsequent thereto, and we can recognize these three immediately. They are definite and distinct, indicating a clear and intelligible idea of the time implied.

The secondary or *historic* tenses are also three—(1) imperfect, (2) aorist, (3) pluperfect; as, ἔλυον, I was loosing, or I loosed; ἔλυσα, I loosed; ἐλελύκειν, I had loosed. They are *historic* because they indicate a relation to some time previous to the immediate past, which the present tends every moment to become; and *secondary*, because each of them is regarded as being formed from a corresponding primary tense. This relation is a twofold one—(1) to the past generally, and (2) to some fixed point in that past. In this way we see that, by their tenses, the Greeks, while they denote the time, also connote the quality of an action; that is to say, they endeavour to indicate whether the action is (1) simple, or habitual and repeated; (2) begun and attempted only, or finished; and (3) of temporary only or of permanent interest. Besides these primary and more important tenses, each of the *leading* tenses has a corresponding *second*, which takes the same stem, and has a certain connection in meaning.

Many Greek verbs have a second aorist active and passive, and a second perfect; as, λείπω, I leave, which from the verb-stem λιπ takes the second aorist active, ἔλιπον, I left, the second aorist passive, ἐλίπην, I was left, and the second perfect, λέλοιπα, I have left. There are also in the passive or middle voice a second future; as, τριβήσομαι, I shall be bruised; a third future, or future perfect; as, λελύσομαι, I shall have been loosed, or I shall have loosed for myself; and a second aorist middle; as, ἐπιθόμην, I obeyed, from πείθω.

There are nine tenses, therefore, represented in the usual paradigms of Greek verbs—(1) present, (2) imperfect, (3) perfect, (4) pluperfect, (5) first aorist, (6) second aorist, (7) first future, (8) second future, and (9) paulo-post future. The last of these is, however, peculiar to the passive voice.

There is a special termination appropriated to each person in each tense. Thus we have several elements all requiring to be concisely indicated in one verbal form; *e.g.* in λυ-σ-ω-μεν (which is the first aorist subjunctive), λυ is the *stem*, σ the *tense characteristic*, ω the *modal vowel*, and μεν the *person ending*. A careful and observant study of these will be of much service in simplifying the acquisition of a full and accurate knowledge of the Greek verb.

Each leading tense and its corresponding second have a stem peculiar to themselves. The letter pointing out the tense, and ending this *secondary* stem, is called the "tense characteristic;" as, σ is the tense characteristic of the future, λύ-σ-ω, and of the first aorist, ἔ-λυ-σ-α, and κ (or in some verbs ἀ) of the perfect and pluperfect. While λυ is the stem proper of the whole verb, λυσ is the *secondary* stem of the future and the first aorist, and λελυκ of the perfect.

Tense forms are *etymologically* of two kinds—(1) strong, and (2) weak. The former affix to the verb-stem a syllable beginning with a *vowel*, the latter add one with a *consonant*; as, ἔ-τυπ[ον], τε-τυπ[α]; τυψω, τυπ[σω]; ἔτυψα, ἔτυπ[σα]. The various tense forms are inflected from either (1) the present stem or (2) the verb-stem. (1) Those formed from the present stem are the present and imperfect—active, passive, and middle. (2) Those formed from the verb-stem and of *weak* form are, (*a*) the second perfect, pluperfect, and aorist active; (*b*) the second aorist middle; and (*c*) the second aorist and second future passive. (3) Those formed from the verb stem and of *strong* form are (*a*) first future active and middle, (*b*) first perfect and pluperfect active, (*c*) first aorist active and middle, (*d*) perfect and pluperfect passive, (*e*) third future passive, and (*f*) first aorist and future passive.

I. From present stem λέιπω we have ἔιλειπον, λείπομαι, ἐλειπόμην.

II. From verb-stem λιπ—(Infinitive λιπειν)—we have, with vowel affixes, λέλοιπα, ἐλελοίπειν, ἔλιπον, ἐλιπόμην, ἐλίπην.

III. From verb-stem λιπ we have, with consonantal affixes, λείψω, λείψομαι, λελειφα, ἐλελειφειν, ἔλειψα, ἐλειψάμην, λέλειμμαι, ἐλελείμμην, λελείψομαι, ἐλείφθην, λειφθησομαι.

It is to be noted that the foregoing scheme of the derivative formation of one tense, as it were, from another is rather a convenient arrangement or grouping of tenses having like characteristics, as an aid to memory, than a statement of the necessary forms of growth taken by the verb in its progress from the expression of the simple to those of the compound relations of activity and life. All the tenses—except the present and imperfect—may, in fact, be formed by adding certain well-defined tense-endings to the verb-stem, if the laws of euphony (in regard to which the Greeks were especially particular) are duly observed in the processes of affixing them; and by prefixing, where necessary, the augments and reduplications which certain tenses require.

In order that we may be able to conjugate a Greek verb properly we require to know (1) the verb-stem, and (2) the present stem. In some cases these are both alike, as in the syllable in brackets in the following—[λεγ]-ω, I say; [λυ]-ω, I loose; in others, a euphonic process of strengthening has taken place in the present stem, as in [τριβ]-ω, I rub, and [λειπ]-ω, I leave, of which the verb-stems are τριβ and λιπ. The stem is that portion of the verb to which, when pure (*i.e.* unaltered or in its simplest form), the flexional changes are added. The pure stem usually consists of (1) a consonant and a simple vowel, as in [αγ]-ω, I lead; [τι]-ω, I honour; βε[βα]φα, I dipped, &c.; (2) two or more consonants with a vowel between them, as in [μέν]-ω, I remain; [τρέφ]-ω, I nourish; and (3) one or more than one consonant and a diphthong, as in [παυ]-ω, I cause to cease; [και]-ω, I kindle; [κλαι]-ω, I bewail. The final letter of a pure stem is called its characteristic; as, [τυπ] in τυπτω, in which π is the *stem* characteristic, and τ is the *tense* characteristic. Stems which *may* take different vowels are called *variants*; as, [τρεφ]-ω, ἔ[τραφ]-ην, τε[τροφ]-α. The present stem is often altered from the pure verb-stem (1) by lengthening the vowel, as in [κλιν]-ω, I bend, from stem κλιν; [φεύγ]-ω, I flee, from φύγ. The most usual forms of lengthening are α into η or αι, ε into ει, ι into ει or ι, υ into ευ or υ. (2) By strengthening the characteristic of the stem by adding (i.) τ, (ii.) ι, which is usually coalescent, occasionally transposed, or (iii.) changing or doubling the consonant, as in [τύπτ]-ω, [φαιν]-ω, from a pure stem, φαν, I strike; [βαλλ]-ω, I throw; [κράζ]-ω, from a pure stem κράγ. (3) By inserting (i.) a consonant or (ii.) a syllable, as in δαμ[ν]-ω, I subdue; δοκ[ε]-ω, I think; ευρ[ισκ]-ω, I find; λα[μ]-β[αν]-ω, I take. (4) By prefixing a reduplicative form (i.) simply, (ii.) euphonized; as, [μι]μν-ω, I remain; [τι]θημι, I place; [ἵ]στημι, I cause to stand, set up.

The scholastic Greek grammarians used to present the verb to the students in thirteen different conjugations—(1) six barytone, (2) three circumflex, and (3) four ending in μι. The first received their designation from their taking the grave accent on their last syllables; the second from their being contracted verbs in άω, έω, and οω—the contraction being indicated by the circumflex; and the third being the old form, few in number, and having few tenses. But—as Dr. J. W. Donaldson suggests—for the practical convenience of the learner, the best arrangement of the Greek conjugations is that which recognizes two classes of verbs—viz. A, primary verbs in μι, and B, secondary verbs in ω, which class is to be subdivided according to the root or characteristic letters into (1) consonantal or semi-consonantal verbs, and (2) vowel verbs which admit of contraction. We shall, however, follow the ordinary practice of modern grammarians by treating in the first place of verbs in ω, and thereafter of verbs in μι.

Of verbs in ω the consonantal or semi-consonantal verbs

may be arranged in six subclasses: in *four* according to the characteristics of the stem; and the vowel verbs in ω in *two*—viz. consonantal stems ending in (1) labials; as, τέρπω, τρίβω, γράφω, τύπτω; (2) gutturals; as, πλέκω, λέγω, βρέχω, τίκτω, τάσσω; (3) dentals; as, ἀνύτω, ἐρείδω, πείθω, φράζω; and (4) liquids; as, ἀγγέλλω, νέμω, κρίνω, σπείρω, τέμνω; and those having vowel stems, (1) uncontracted, as λυω; (2) contracted, as τιμάω, φιλέω, δουλόω.

The following tabular view of the six subclasses of verbs in ω, with the characteristics of their principal tenses, and examples of the formation of their chief parts will help to make the tense formations, to some extent, simple and readily understood.

The principal parts of a Greek verb, arranged according to voice and tense, are:—in the active, (1) present, λύω; (2) future, λύσω; (3) perfect, λέλυκα; and in the passive, (4) future, λυθήσομαι; (5) perfect, λέλυμαι. Examples of these in all the several classes are given in order below. Analogy in conjugation, however, is so often founded on insufficient materials, or pursued in such false methods, and dialectic peculiarities so often occur, that it is impossible to indicate every irregularity. Besides, many verbs are defective. Hence, in the table, tenses which are never found are omitted, and those which seem doubtful are put in parentheses.

Class I., of which the characteristic letters are π, β, φ, πτ; the future ends in ψω, and the perfect in φα.

Class II., of which the characteristic letters are κ, γ, χ, κτ, and σσ; the future ends in ξω, and the perfect in χα.

Class III., of which the characteristic letters are τ, δ, θ, and ζ; the future ends in σω, and the perfect in κα. Many of the verbs which have ζ for their characteristic, have their future ending in ξω, and their perfect in χα.

Class IV., of which the characteristic letters are λ, μ, ν, ρ, μν; the future ends in ω, and the perfect in κα.

Class V., of which the characteristic is that the vowels ι, or υ, or the diphthongs αυ, ει, ευ, precede ω; the future ends in σω, and the perfect in κα.

Class VI., of which the characteristic is the vowels α, ε, and ο occurring in two conditions—viz. (1) forming the future and the perfect with a long vowel before σω and κα; and (2) having a short vowel before σω.

Characteristic.		Present.		Stem.	Future Active.	Perfect Active.	Future Passive.	Perfect Passive.
Class I., having Labial Stems.	π	τερπω,	I delight	τερπ	τερψω	τετερφα	τερφθησομαι	τετερμαι
	β	τριβω,	I rub	τριβ	τριψ	τετριφα	τριφθησομαι	τετριμμαι
	φ	γραφω,	I write	γραφ	γραψω	γεγραφα	——	γεγραμμαι
	πτ	τυπτω,	I beat	τυπ	——	——	——	τετυμμαι
Class II., having Guttural Stems.	κ	πλεκω,	I weave	πλεκ	πλεξω	πεπλεχα	πλεχθησομαι	πεπλεγμαι
	γ	λεγω,	I say	λεγ	λε[illegible]ω	(λελεχα)	λεχθησομαι	λελεγμαι
	χ	βρεχω,	I water	βρεχ	βρεξω	——	——	βεβρεγμαι
	κτ	τικτω,	I beget	τεκ	τεξω	τετοκα	τεχθ[illegible]σομαι	τετεγμαι
	σσ	τασσω,	I order	ταγ	ταξω	τεταχα	ταχθησομαι	τεταγμαι
Class III., having Dental Stems.	τ	ἀνυτω,	I finish	ἀνυτ	ἀνυσω	ἤνυκα	ἀνυσθησομαι	ἤνυσμαι
	δ	ἐρειδω,	I prop	ἐρεδ	ἐρεισω	ἐρηρεικα	——	ἤρεισμαι
	θ	πειθω,	I persuade	πιθ	πεισω	πεπεικα	πεισθησομαι	πεπεισμαι
	ζ	φραζω,	I tell	φραδ	φρασω	πεφρακα	——	πεφρασμαι
Class IV., having Liquid Stems.	λ	ἀγγελλω,	I announce	ἀγγελ	ἀγγελω	ἤγγελκα	ἀγγελθησομαι	ἤγγελμαι
	μ	νεμω,	I divide	νεμ	νεμω	νενεμηκα	νεμηθ[illegible]σομαι	νενεμημαι
	ν	κρινω,	I judge	κριν	κρινω	κεκρικα	κριθησομαι	κεκριμαι
	ρ	σπειρω,	I sow	σπερ	σπερω	(ἔσπαρκα)	(σπαρθησομαι)	ἔσπαρμαι
	μν	τεμνω,	I cut	τεμ	τεμω	τετμηκα	τμηθησομαι	τετμημαι
Class V., having uncontracted Vowel Stems.	ι	τιω,	I honour	τι	τισω	——	——	τετιμαι
	υ	λυω,	I loose	λυ	λυσω	λελυκα	λυθησομαι	λελυμαι
	αυ	παυω,	I stop	παυ	παυσω	πεπαυκα	παυθησομαι	πεπαυμαι
	ει	κλειω,	I shut	κλει	κλεισω	κεκλεικα	κλεισθησομαι	κεκλειμαι
	ευ	κελευω,	I command	κελευ	κελευσω	κεκελευκα	(κελευσθησομαι)	κεκελευσμαι
	ου	λουω,	I bathe	λου	λουσω	——	——	λελουμαι
Class VI., having contracted Vowel Stems.	α	τιμαω,	I honour	τιμα	τιμησω	τετιμηκα	τιμηθησομαι	τετιμημαι
	ε	φιλεω,	I love	φιλε	φιλησω	πεφιληκα	φιληθησομαι	πεφιλημαι
	ο	δηλοω,	I show	δηλο	δηλωσω	δεδηλωκα	δηλωθησομαι	——
	α	γελαω,	I laugh	γελα	γελασω	——	γελασθησομαι	γεγελασμαι
	ε	κορεω,	I satisfy	κορε	κορεσω	——	κορεσθησομαι	κεκορεσμαι
	ο	ἀροω,	I plough	ἀρο	ἀροσω	——	——	ἀρηρομαι

heels together, throwing the forefoot backward, and stretch out the legs in line with the body in a position to resume stroke 1, &c. After these can be repeated easily by number and in order, perform both members of each series simultaneously with legs and arms, until the exercise has transformed the directions into habits, and a good distance can be overtaken with ease and speed, yet without fatigue.

Floating and swimming on the breast are the most essential means of motion in the water. But, as in almost everything else, necessity and luxury have led to the adoption of several modes of progression. When fatigue overmasters one while swimming in the usual fashion, it is often convenient to give the muscles rest by floating or swimming on the back. This may be done, according to choice or need, either with head or feet foremost. In the latter case, (1) the head is thrown back as far as possible, making sure that the swimmer keeps the water from his mouth; (2) the hands are pressed downwards and backwards with the palms scooped; by these means the feet will rise to the surface, and then (3) the hands are used by a quarter circle movement for propelling the body by continuous strokes, taking care meanwhile (4) when the outward stroke is completed, the hands, turned edgewise to ensure the least resistance, are brought gently upwards and inwards towards the sides, when they are ready for a fresh stroke. It is a recommendation of this mode of progression that one, while the hands are down in the water, can raise his head and see where he is, and how, as to direction, he is going. In the former case, *i.e.*, proceeding head first, one may secure safety and progress by (1) using the rotary motion of the hands already described, (2) pushing forth the feet from the body with the toes close and the soles flat against, but completely under the water, or (3) employing both means simultaneously or successively. The last-named mode secures great speed, requires little exertion, and affords intervals, even though brief, for alternate relaxation and rest.

There are a good many sportive and fanciful methods of swimming occasionally employed in displays and matches, but these are generally more showy than useful, and many of them are the mere specialties of professional experts in aquatics—difficult to describe with accuracy. Hand-over-hand swimming is a rude practical means of progression, mostly employed by savages when they wish to swim rapidly; but it requires great exertion and has little to commend it, except as a curiosity of the art. Swimming on the side is considerably more useful and enables the practitioner to make great speed when once acquired. The method may be briefly summed up thus: (1) raise the left shoulder towards the surface, (2) stretch forward the *right* arm along the surface, (3) hollow the palm, and (4) draw it back through the water towards the chest. Thereafter (5) use the *left* arm, palm flat but thumb downwards, to push back like an oar the water towards the feet, and (6) strike out with the feet in the usual way. Alternate the strokes of the right and left hands; but let the feet movements always be made simultaneously with the left hand ones.

Treading the Water.—The art of treading the water is simpler than it seems. If the body is laid on its back in fresh water, the legs and the lower part of the body will gradually sink till it assumes an upright position in the water. When in that posture, if the head be thrown quite back, the face will be floated so as to give free breathing. At every inspiration it will rise, and at every expiration sink an inch, but, as air is at least 800 times lighter than water, so long as breathing is kept up the mouth will not be covered. Then by stretching out under the water the arms, which possess one-tenth of the buoyancy of the entire body, this will keep the person floating so long as the upright posture is maintained. The balance of the body is effected and preserved by putting one foot before the other alternately as if walking, and so "treading the water," as in fig. 14. Some advise as a more invigorating exercise, and as peculiarly beneficial to sufferers from indigestion or constipation, a more active style of treading the water than this. Their method is, when the body is completely immersed in the water, the body perpendicular and the face turned fully upward for free inhalation, to (1) cross the arms over the chest, (2) draw up the legs to the hips alternately, and (3) thrust each of them down again in turn with vigour. These motions act as a powerful and wholesome stimulus to the whole of the vital functions of

Fig. 14.

the lower parts of the body, and the lower limbs are greatly strengthened.

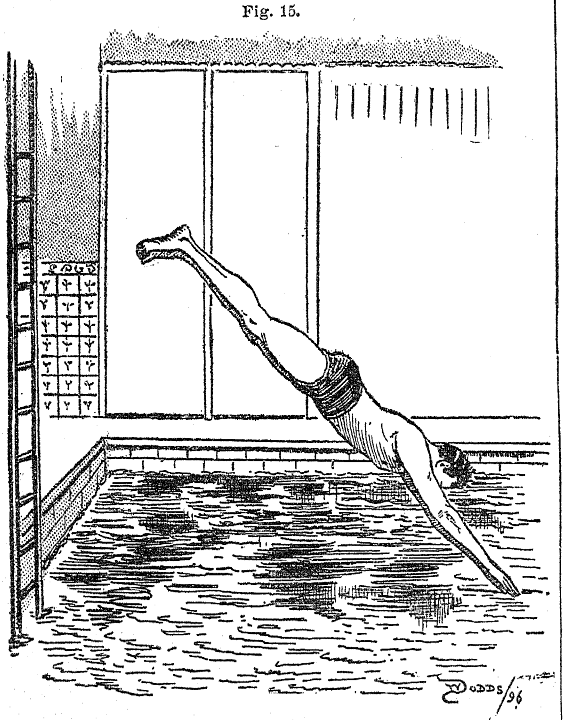
Diving.—Diving is the act or art of descending rapidly, of one's own accord, into water, and calls for skill and cleverness in its adepts. Learners ought to be careful to dive at first in places where they know the water is neither too shallow nor too deep. If the former, they may injure themselves by coming too suddenly against the bottom; if the latter, surprise may overtake and disconcert. The safest plan is to choose a place with the depth of which you are acquainted, to bend down till nearly doubled, to stretch out the arms over the head till the fingers meet; to lean over the water till the surface is almost touched, and then drop in. This will accustom you to the surprise felt, and let you know how the buoyancy of the water helps you to rise. Afterwards try a running leap from the side into the water, following the previous directions, but doing all more quickly. A boat, a spring-board, may next be used to dive from, and then a ladder, from the steps of which the diver may plunge, going higher as he improves and grows bolder. The expert diver repeatedly raises his arms over his head and draws them rapidly back, till the elbows reach the side. This is done to expand the chest and improve the breathing. Putting the ends of his fingers and thumbs together, he then throws his arms, the hands being joined right above his head, bows his head between them with chin near the neck, curves his back concavely, stiffens and straightens his body, stretches his limbs, sets his feet close together, and so, all in the same straight line, forming a perpendicular statue-like figure—taking a full breath and closing his eyes—he plunges, head foremost, cuts down into the water with no very great splash, and glides through it with the speed of an arrow till the impetus gradually exhausts itself. Care must be taken that the hands form a wedge-like cut-water; that the head is so bent that the shock of the impact on the surface may be received on it, not on the chest or stomach, and that not the least alteration of the attitude of the body should occur as it enters the water. See fig. 15.

Some swimmers advocate diving feet foremost. In doing so the head is drawn back; the arms and hands are pressed close to the sides, palm inwards; the thighs and legs kept close together, with the feet bent down, and the heels and toes firmly held together. Thus, in a straightened compactness, the body is dropped into the water with a safe entering

impetus, not so graceful, but quite as effective, as the bounding header.

We now, for use in remembering the points in practice, number in order the elements of diving:—(1) Stand erect upon the bank or plank close to, or having the toes even

Fig. 15.



over, the edge or ledge; (2) stretch the arms right up from the shoulders till the fingers meet over head and the ears are covered; (3) lower the head with the hands outspread before it; (4) let the body fall head foremost into the water with the hands still joined as a safeguard and a cut-water to cleave it; (5) curve the spine concavely as soon as the body is in the water, (6) throw the head up back in order that the body may the sooner rise to the surface, and then strike out—whithersoever you wish.

In diving from a boat do so from the stern, where there is firmer footing, rather than from the side, where the footing is least favourable; and, by the by, when desirous of entering a boat from the water, do so at the stern too. When swimming towards the boat's stern—unless a rope or a ladder is available—swim with the feet high, and when grasping tread with the feet to keep them up, otherwise you may be sucked under the boat, or at least have your shins cracked against the boat while making your way into it.

Plunging resembles diving rather as a means of entering the water than in anything else. It is the art of gaining an impetus from making a spring or leap from a height above the surface of the water into it. To accomplish it neatly and powerfully requires both skill and strength. The position taken may differ according to taste. The most important things requiring attention are—(1) that the point of poise should be the ball of the foot, (2) that the knees be kept close together and slightly bent, (3) that both arms be held backwards, as in jumping, (4) that the lungs be fully charged with air and the chest inclined forward, (5) that the body be then crouched for a spring and the spring taken with the whole power of the frame, (6) that the arms be then swung forward from behind, thrown out in the direction of and beyond the head, and (7) that the head be dropped upon the chest so that the ears may lie between the biceps (see fig. 16). When the body is fairly under water, lay the hands flat, interlock the thumbs and keep the arms stifly outstretched in front of the head as far as possible. The shoulders are thus contracted and hollowed and the chest expanded. The hips, knees, ankles, instep, and toes are to be kept stretched out so as to have the flat of the soles facing upwards to the surface. The body, with its muscles motionless and the limbs rigid, will, with the impulse gained by the spring, move floatingly along the surface so long as the breath keeps the body buoyant. When the feet sink the force is spent, and the plunge is over.

The plunge has come to be much used at the *starting signal* in swimming matches, and is, if the distance be short, of considerable advantage because it enables the adept to get clear of the crowd of starting competitors, who dive and do not plunge, and if done with skill and power carries the expert beyond the average of them before he begins to swim:

Fig. 16.

and thus he gets on with a clear course. It is also commended as likely to be of great use in effecting an escape from a wrecking vessel as affording a chance of getting beyond the dangers of the drifting boats and the suction of the water if any were to sink. Bathers should at all times be careful as to the nature of the water into which they plunge, and should carefully avoid that in which there are beds of weeds, or strong currents or tides. What is principally to be guarded against in fresh water is the presence of cold springs.

Experienced divers and swimmers—but these only—should occasionally practise their pastimes with less or more of their clothes on, that they may be able, on emergency, to give aid even when so encumbered. Though water is some 800 times heavier than air, the water that saturates the clothes and feels so heavy when we emerge, does not while we are in the water affect us by its weight. It is rather the clinging of the wet garments that impedes. The ordinary strokes cannot be taken with so much freedom, and require to be taken with greater deliberation and somewhat more strongly, so that the muscular force may overcome the hindrance to their free motion, and should therefore be more decidedly and carefully taken.

In attempting to rescue a drowning person, the swimmer should approach him from behind and endeavour to get a grasp either of the hair of the head or the upper part of the arms, so as to prevent him from closing with or clutching the rescuer in a manner that would deprive him of the power of using his arms or legs; for should the drowning person once get a clutch of his would-be deliverer, the consequences might be fatal to both. Persons subject to cramp, or troubled with any heart affection, should on no account venture beyond the reach of aid, lest such should become necessary; indeed, it would be well for such persons not to go beyond their depth.

CHAPTER IV.

FOOTBALL.

To the young, whose vigour is fresh and whose need for practical physical exertion is intensely felt, football commends itself as an attractive amusement. Its very dangers give it charm, and have a beneficial and educative influence upon the disposition. The strong endeavours, personal and combined, in which that game induces folk to work together for a common end, make it a favourite pastime with those who wish to train their muscles and to test their strength. It is not given to everyone to be a cricketer or a don at lawn tennis, but almost all who possess ordinary bodily power can manage to do something in "the give and take" of the famous game of football. It is, in its origin and essence, a simple strife of strength, a healthy mimicry of war, having something to gain as a proof of prowess and a token of success. The ball itself is trivial, but the triumph in trial gives it worth. It is the evidence of superiority in stamina and perseverance. Onlookers at the competing players may think, as Waller says, that—

> "Care of victory
> Makes them salute so rudely breast to breast,
> That their encounter seems too rough for jest."

But the hardships, the roughnesses, and even the casualties undergone in the course of a game are rejoiced in. That this is the case can need no proof to any who have seen the enthusiasm evoked in a football contest got up in villages or country districts at Candlemas in Scotland or Shrovetide in England, where art, added to activity, but quite unfettered by aught except custom and tradition, filled players and spectators alike with fire and liveliness as effort and energy were freely expended for the mere pleasure of the play. In these almost unhampered sports, the goals, the gaining of which ensured success, were generally some familiar objects not too far apart; a church, a mill, a bridge, a gateway, a pillar, a garden-wall, the gable end of a cottage, or two well-known trees, served the purpose, while the roadway between formed the bounds of play.

"Football as it is" has been hitherto engaged in and played under many differing "codes." Within the last half century efforts have been made to lessen provincialism of play. These have been received with a good deal of favour. Some success has indeed attended the movement, but uniformity has not yet been entirely achieved. "The Rugby Union" and "The Football Association" are the two leading bodies who issue authoritative "Rules for playing Football," and the adherents of either form separate sects of wrestlers for the bringing in of "the leathern sphere" to the goal.

The recognized football season extends from 1st Sept. of one year to 30th April of the following one, and contests or matches—except charity or practice ones—are discouraged in the intervening months. At the annual general meeting of the Football Association, held in the month of May in each year, the laws of the game are revised, and, where found necessary, amended; but these as then fixed do not come into force until the beginning of the football season next ensuing. The general meeting of the Rugby Union for the consideration of any proposals made for altering, rescinding, or adding to any of the bye-laws or rules is held in the month of March, and such amendments, additions, or alterations come into force in the subsequent season. Each club, duly connected with either corporation, is furnished with a copy of such bye-laws and laws, and the members of each body, respectively, are held bound neither to commit or permit any wilful infringement of them. The decisions come to at these meetings are generally reported in the public prints at the time, and these, as well as the text of the rules, will be found in the "Football Annual," with which every set of footballers should be provided.

Like every other sport which has endeared itself to the heart of our nation, football involves a contest of power and a struggle for success. It is made intrinsically attractive by the persistency and skill required, in the constantly changing phases of play, to keep up the apt competition necessary to score a victory. "To gain a goal" is *par excellence* a common phrase for to win, by a combination of activity and ability in a fair field, in an equally-conditioned contest.

THE RUGBY GAME.

The Rugby Football is a complete and complex systematic and, in some measure, scientific game. Its exhilarating open-air freshness, as well as the invigorating exercise it yields, have secured it a long tenure of public favour. Its educational effect in training to wholesome rivalry and speedy decisiveness of action is highly beneficial. It has been found an excellent pastime for growing youths, whose exuberant vitality it works to good uses in the development of *physique* while the muscles are elastic and pliable, the joints flexible, the bones rich with self-upbuilding force, and the spirit responds readily to stir and bustle; and, if honestly played in accordance with the rules, it animates and enlivens every function of the frame favourably.

The number of players in the Rugby game is *fifteen* a side. Each fifteen constitutes a *team*—yoke-fellows true, whose object is to outdo the rival team. Each side is commanded by a captain, who acts as representative of his team, and regulates its play in relation to the rival team with which it is to compete in the glowing game and on the field of play. His duty and right it is (1st) to assign their respective places in the field to the players; (2nd) to keep them in play, on their own side, in order that no one may be "put off-side," and so mar the game; and (3rd) to see that fair play is made by his own side and given by his rivals, and to combine, in fact, dutiful discipline and cheerful efforts for his side's success. He requires to see that his team makes its appearance in the field in good trim, fettle, and form, rightly equipped with their distinguishing dress and badges, and with no objectionable foot-gear. The Rugby rules enact that "No one wearing projecting nails, iron-plates, or gutta-percha on any part of his boots or shoes shall be allowed to play in a match."

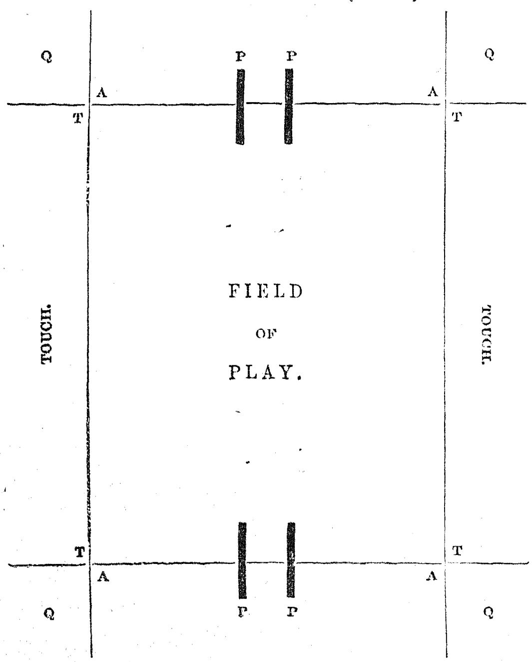
The *ball*—sometimes aptly called "the Footer"—formerly used in the Rugby game, consisted of a strong ox-bladder blown to the requisite size and tenseness (by being filled with air), and then covered with thick close-fitting leather laced tightly round it. India-rubber bladders, as affording a better balanced ovalness of form, are frequently used, although they are regarded as being inferior, even when strongly cased and skilfully laced. The precise dimensions worked to by the best makers are thus stated—"A ball, oval in shape, 11 to 11½ inches in length; 30 to 31 inches in circular length; 25½ to 26 inches in circular girth; hand-sewn, with not fewer than eight stitches to the inch." In weight it may vary from 13 to 14½ ounces when it is placed dry on the ground ready for use. In case of mischances it is generally a wise precaution to have an additional ball or two at hand during a match. The dress worn—when not fixed by club rules or by common custom—should be of some light and porous woollen texture, made so loosely as to allow of the free and unconstrained movement of every limb and muscle, and yet closely adhering to the person.

The Rugby Rules are numerous and technical, and require careful study. By those who are familiar with the history and practice of the sport as pursued by those who have been trained in Rugby the rules are readily understood, because experience and observation interpret the words in which they are couched.

The preliminaries of the game are distinctly set down in the Rules of the Rugby Union. The first essential is a field of play so laid out as to afford accommodation for those who are to take an active part in the game, and so enclosed as to protect it against the intrusion of spectators and the interruption of the play. In the annexed plan (next page) the form, dimensions, divisions, and dividing lines of the Rugby Field are shown and explained. Each goal is "composed of *two* upright posts, exceeding 11 feet in height, and placed 18½ feet apart, with a crossbar 10 feet from the ground" (4). "*Over* this cross-bar the ball must be kicked directly from the field of play to obtain a goal" (5). "In all matches two Touch Judges shall be appointed, and a Referee must be chosen with the consent of the secretaries or the captains of

the respective contending bodies of players" (49). "The captains of the respective sides shall toss up before the commencement of the match; the winner of the toss shall have the option of choice of goals or the kick off" (35). "Each side shall play from either goal for an equal time" (34). The time most usually arranged is thirty-five minutes each way. "The referee shall be timekeeper, and on any questions of 'time' his decision shall be final." These matters having been settled the captains see (1) that the full-backs take their places in their respective goals, "for a safe and well-kept

PLAN OF THE FIELD (RUGBY).

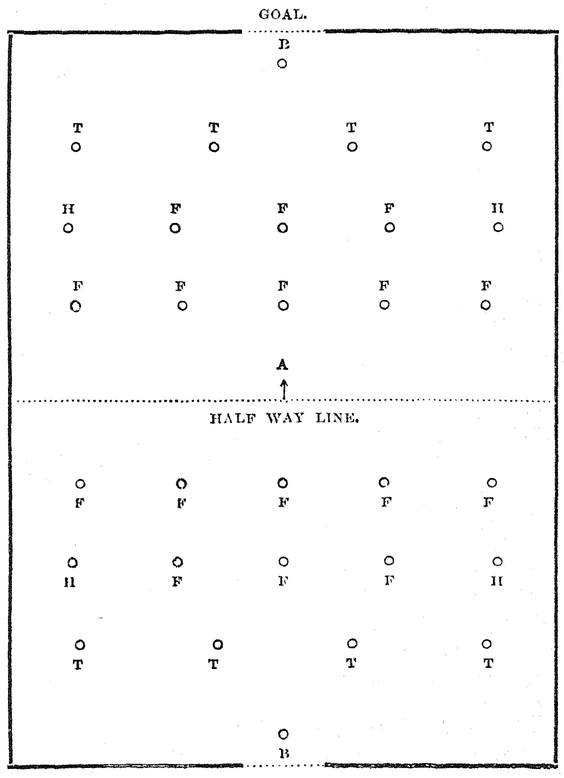


Explanation of Lines and Letters.

A, A. Lines of Goal. P, P. Goal Posts.
Q, Q. Touch in Goal. T, T. Lines of Touch (110 yards).

goal is the foundation of all good play;" (2) that the other "backs" have deployed themselves properly; and (3) that the "forwards" are well disposed in fighting form and trim to play their part. The goal chosen is that which is to be defended against attack; the kick-off, given at the commencement of the game, is the first act of aggression made by the assailants on the stronghold of their rivals, who hold their own half of the field clear, and are prepared to resist their antagonists in the warfare of the whirling ball. The toss-winner proceeds to the centre of the field, where the ball lies ready for a *place-kick—i.e.*, a kick at the ball "while it is lying in a *nick* or slight hollow made in the ground for the purpose of (1) keeping it at rest" (2) in the position he wishes it to occupy. The players on either side must stand at a proper distance from the ball until the kick has been given—viz., the kicker's side distinctly behind the kicker when it is kicked off, and the opposite side "at least 10 yards in front of the kicker until it is kicked off" (32), otherwise "the referee shall order a scrummage" (which will be explained in due course) to be formed. Prior to giving this kick-off the kicker-off may take a run of a few steps. As the assailed, the goal-holders act mainly on the defensive, that they may preserve, at all hazards, the citadel of which they have by lot been placed in charge, and, if necessary and possible, bear down upon their rivals and carry the encounter into their ground and against their goal. The aggressors, having taken precautions against such a siege, and being resolved to gain the goal into which they have undertaken to press, endeavour to maintain and improve the initiative already conceded to them in the kick-off by advancing their main invading force into the ground of their sisters. They rebuff such inroads, and hurl back the ball with opposing energy. The spirit of rivalry is evoked. "Forwards" join issue with Forwards, prowess and skill are exerted with eagerness by each side, and the enclosed space on which the tournament is held speedily becomes busy with effort and counter-effort to secure the token of victory—a goal. Like true knights, however, footballers, eschewing savagery in their martial encounters, have agreed to moderate their zeal and civilize their sport by compact and regulation. Experience and reason prevail over haste and passion. If the ball kicked off does not go into touch and is got hold of with a "fair catch" by any one of the opposite side, while no one on the catcher's side has touched the ball, he may instantly make a (dinted) mark with his heel at the spot where he made the catch. This having been done, the player may either take (1st) a drop-kick, or (2nd) a punt, or (3rd) place

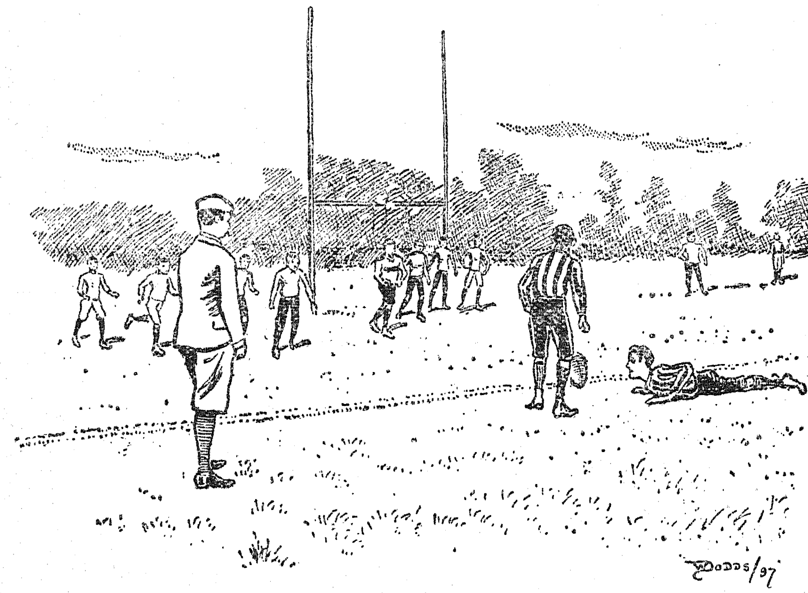
POSITION OF PLAYERS BEFORE KICK-OFF.



A, The Kick-off. F F, The Forwards. H H, The Half-backs.
T T, The Three-quarter Backs. B, The Full Back.

the ball for a place-kick (43). In every case of this sort, the players on the opposite side may come up to the dinted mark, and the catcher's side retiring, the ball shall be kicked by him either from that mark or from a spot any distance behind it, in a straight parallel line with the touch-lines (44). "A *drop-kick* is made by letting the ball fall from the hand and kicking it at the very instant it rises" (1), and a *punt* "by letting the ball fall from the hands and kicking it before it touches the ground" (3). In all cases, except a *punt out* and a *punt on* [when allowed], "the kicker's side must be behind the ball when it is kicked, yet may not *charge* until it has been kicked;" but "the opposite side, in the case of a punt out or a punt on, and the kicker's side in *all* cases, may not *charge* until the ball has been kicked" (56). A *charge* is a rush or onset made by the attacking party where the ball is, either to kick the ball or to tackle any player who is holding or running with the ball. In the event of a tackle the holder or the runner "must at once cry 'down,' and immediately put the ball down" (18). If he does not instantly

conform to the law, or if he, being on the ground, has not immediately got up, the referee "shall, on a claim from the opposite side, award a *free-kick;* and this penalty-kick must be taken in the manner described above as that taken by the gainer of a "fair catch" (26 and 44). Such a free kick, if taken as a drop one, may be converted into a goal.



A Free Kick.

more favourably placed for going in and gaining. He may often swoop on an opposing forward by a rush from the side at right angles. The full-back should be a skilful and well-practised kicker, able to punt or drop with either foot unfailingly. The former is generally the safer, and his endeavour should be to make the ball land in touch. He should be a judicious tackler. A brisk and clever tackle generally puts a stop to a run. An opponent who has evaded or broken through the three-quarters should be tackled—but let it not be done with arm round the neck, at the shoulder or waist —in a word, never tackle high — tackle low, mostly round the legs.

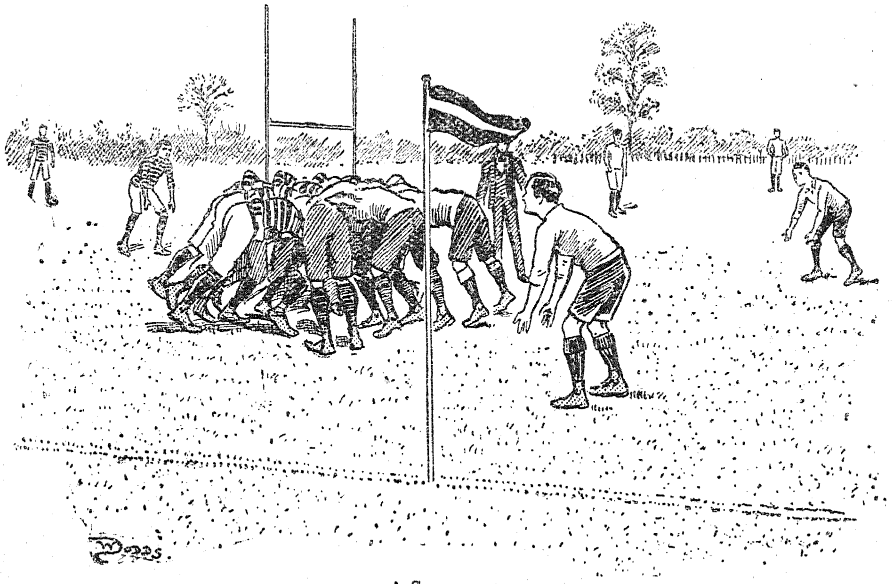
When an unlawful charge is made by any of the opposite side—before the player having the ball commences to run or offers to kick or the ball has touched the ground — the referee may award a free-kick. A free-kick may also be claimed "in case any player touches the ball wilfully when off-side;" "if any player when off-side tackles, or in any way interferes with an opponent before such opponent has run 5 yards or taken his kick;" "if, on a throw-out from touch, the ball shall be knocked on." In these cases the alternative is allowed of claiming that a scrummage should be formed (23, 30, 41).

Having this general idea of the game before us we must now explain the organized order and respective duties apportioned to the several players. The teams are ordinarily thus arranged—one full-back, four three-quarter backs, two half-backs, and eight forwards. The last-named are the main strength of each side, and hold the open field. They may have allotted to them wing or centre play, as discretion and ability suggest; but though they may have been thus specialized, they must all work combinedly in facing their opposers. Half-backs have to do most of the running and tackling, and should be alert, agile, and plucky. They go between the forwards and the three-quarter backs—playing from the one to the other as need and opportunity occur. Behind weak or losing forwards, they get hard work, and often hard words. An acceptable back ought to have a good understanding personally—and with his co-partner. When a scrummage (p. xviii) is on, one Half works it watching the progress of the ball. In doing this, he should station himself about 2 yards behind, so that he may be able to seize the ball the very moment it emerges from the mixed melée, and pass it to his colleague. He, standing back from 6 to 9 yards off, should be ready to receive it and to pass it to Three-quarters. To go too near the scrummage is dangerous, and to pick out the rolling leather from the scrummage involves peril. The worker should seldom himself try a run, lest his opponents turn and tackle him. When he throws a pass, he should let it be hard and low—just about waist height. He stops the rushes of his opponents when they have routed their rivals—often deftly throwing himself on the ball—always, however, with his head away from the pursuers, and packing the ball into his arm-pit. The ball he may sometimes throw to a near forward—anywhere in his twenty-five yards—who may convey it into touch farther down the line. His throw should be short near his own goal and long near his opponents', and in danger he should punt into touch. Three-quarters, in defence, should be good to kick, save, or tackle. Wary kicking for following up is best; short kicks rising over an opponent's head are often advantageous. A three-quarters having the ball should run with the utmost speed, but if blocked should pass the ball when any one on his side is

The scrummage is regarded as one of the most distinctive features of Rugby play. "A scrummage takes place when the holder of the ball, being in the field of play, puts it down on the ground in the front of him, and all those who have closed round on their respective sides endeavour to push their opponents back, and by kicking the ball, to drive it in the direction of the opposite goal-line." It is usually now formed by eight forwards on each side. These arrange themselves into two rows—a front and a back one—sometimes four in each; at others, three in front and five in rear. Occasionally, especially when the forwards on one side are weak and the three-quarter backs are known to be trustworthy, nine forwards are put on to balance the heavier force of more muscular forwards, and then they form four in front and five in rear. In interlocking for a scrummage, the utmost compactness is advisable. Judicious matching in height is an important point, for the duty of each scrummager is to shove his hardest and wariest, and this can only be well done when

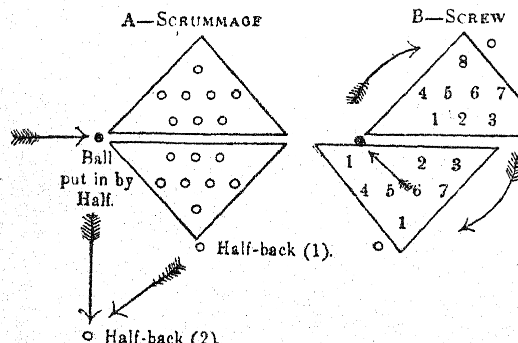
A Frustrated Tackle.

force is opposed to force as directly as possible. The players keenly hemming in the ball, on-side and off-side form a swaying agitated mass; all the technical dexterity in "dribbling" the ball and passing it on from one to another is now required, and all the might of a shoulder-against-shoulder struggle occurs. Players in the front row should take care that their rivals do not get under them, because, by the purchase they thus gain, their power of push will be relatively much increased. To manage to give the first shove is an advantage. To secure solidity of mass and unity of pressure it is indispensable to have both feet firmly planted. The front row should exert themselves to the utmost to gain the ball and pass it on immediately to the second row, who should see to its being driven right through in a proper direction and at a safe point for the backs to possess themselves of it. Meanwhile they must



A Scrummage.

keep a keen eye on the play, that the ball may be either kept in or brought into their own side, and yet carefully preserve their *on*-side; for if any one enters a scrummage from his opponent's side he is off-side and "out of the game" (21). After careful consideration, heeling-out from a scrummage is, by recent decisions, allowed, and is sometimes found to be advantageous, if judiciously done, especially when the scrummage takes place near the goal of one's rivals. If a *screw* is put on, the pressure of the push should be such as to get the rival side away from the ball, and having



succeeded in this, dribble the ball to the half-back. Then their co-partners in the scrummage may turn round and form a back row to them; for forwards do not now-a-days confine their main efforts to the scrummages, but take part in nearly the whole game. They are ready, when opportunity arises, to take and drive and pass the ball as best suits the exigencies of the game, following up every kick, spreading themselves out, and prepared on the instant to conform to the go of the play with skill and zeal. The ideal form of a scrummage—seldom realized in practical field play—may be regarded as assuming a sort of diamond form, arranged *three* in front, *four* in the back row, and *one* acting as a general reinforcer, as in the annexed diagram [A]. When the scrummage is in process of being *screwed*—each side striving to push the other off the ball and to kick it within reach of their waiting half-back—it may assume a changed appearance as one or other of the contending parties manages to shove its rival (more or less) from the object of contest, which may be represented by diagram [B]. In the former the ball is shown about to be thrown in by half-back (1). Having committed it to its fate, he retires behind to watch its issue from the scrummage, so that, as soon as it emerges, at whatever point, he may pass it towards his colleague half-back (2) on the lookout for it. The latter shows the direction in which the half-back on either side should pass the ball, whichever happens to gain it. In a scrummage it is not lawful to touch the ball with the hands under any circumstance. If any one intentionally either handles the ball or falls down on it the referee may award a *free kick* (14), though "a player may take up the ball whenever it is rolling or bounding, except in a scrummage" (12). When the back sees the ball leaving the scrummage, he ought to work it by well-guided dribble and pass down the safest wing side. If the ball is middled, the centre forwards will alertly pounce upon the leather, and hot work will ensue. When a player is hemmed in he should, if possible, punt over his opponents' heads; but unless some player, who was behind him when he kicked, is ready to rush up and dispute possession, any long kick given makes the ball practically the opponents', unless it goes in touch. A ball is "in touch" when it enters "that part of the field on either side of the ground which is beyond the line of flags"—*i.e.*, the touch-lines. When that occurs "it must be taken back and thrown out again." He who played it "into touch" "must then himself, or the half-back of his own side, either (1st) bound the ball in the field of play, and then run with it, kick it, or throw it back to his own side, or (2nd) throw it out at right angles to the touch-line, or (3rd) walk out with it at right angles to the touch-line a distance of *fifteen* yards, and there put it down —having first declared that he intends to walk out" (28). A fair catch may be rightly made while the ball is in the

air, but in no case should a player take up the ball *from* or touch it *on* the ground by the hand, unless to lift and carry it in order to be kicked in any allowable way, as a *drop*, a *place*, a *punt*, &c. However, "a catch made when the ball is thrown out of touch is not [deemed] a fair catch" (31), and "if the ball be not thrown out straight, the opposite side may at once claim "not straight," and a scrummage is formed at 5 yards' distance from the touch-line. In a "throw out of touch" into play the players on each side line out in a straight line, with their faces turned towards the thrower, who faces them directly.

"A scrummage ceases to be a scrummage when the ball is in touch or goal" (11). *A maul in goal* (which is a specific scrummage) occurs when a ball is held inside the goal-line, and one of the opponents' side tries to touch it down in goal. Those players only who are touching the ball with the hand when the maul begins, and only so long as they retain their touch (though only with one hand), shall continue in the maul. The ball shall be touched down when the maul is concluded, and shall, unless the opposite side have gained entire possession of it, belong to the side which first had possession of it; but if it has entirely escaped from the hold of all parties, it shall belong to the defending side (19), and so gives them a try. Even though a try occurs when half-time or no side is called, the kick at goal shall be allowed (50).

A Throw-out.

"A goal may be obtained by any kind of kick [of the ball] except a *punt*;" and a goal is gained only on the ball being kicked *directly* from the field of play (*i.e.*, without touching the ground or the dress or person of any player of either side) *over* the cross-bar *between* the goal-posts, whether it touches such cross-bar or the posts or not; but if the ball goes directly over either of the goal posts, it is not a goal" (5). This is the straightforward course of a general game, though there may occur a few side-issues which it is not very easy to describe or define concisely in good set terms, but a correct knowledge of which can be readily acquired when seen in practice. "When a goal has been obtained, the side which has lost the goal shall have the right of kick-off" (40); and "when goals have been changed at half-time, the side which did not kick-off at the commencement of the game shall then kick-off" (37). "A try at goal is gained when a player touches the ball down in his opponents' goal" (6). A match is decided by the majority of points; a goal shall equal *three* points, a goal gained by a kick from a "penalty kick" *two* points, and a try *one* point; when, however, kicked from a try, the goal only is scored (7). If the number of points be equal, or no goal kicked, or no try obtained, the match is a *drawn* one.

THE ASSOCIATION GAME.

Association players say that the simplicity of the sport gains greatly by adherence to the origin and derivation of the name of the game. It is *foot*ball, and *hand*ling—*i.e.*, playing the ball with the hand or arm—should not be permitted in any circumstances. Their rules forbid the use of the hand by any player except the goal-keeper, and that under restriction, when defending his goal. They prohibit the use of foot-gear likely to hurt by ordaining that—"No player shall wear any nails, excepting such as have their heads driven in flush with the leather, or iron plates, or gutta-percha on the soles or heels of his boots or on his shin-guards. If bars or studs on the soles or heels of the boots are used they shall not project more than half an inch, and shall have all their fastenings driven in flush with the leather. Bars shall be transverse and flat, not less than $1\frac{1}{2}$ inches in length and half an inch in width. Studs shall be round in plan, not less than half an inch in diameter, and in no case conical or pointed. Any player discovered infringing this rule shall be prohibited from taking further part in the game" (11).

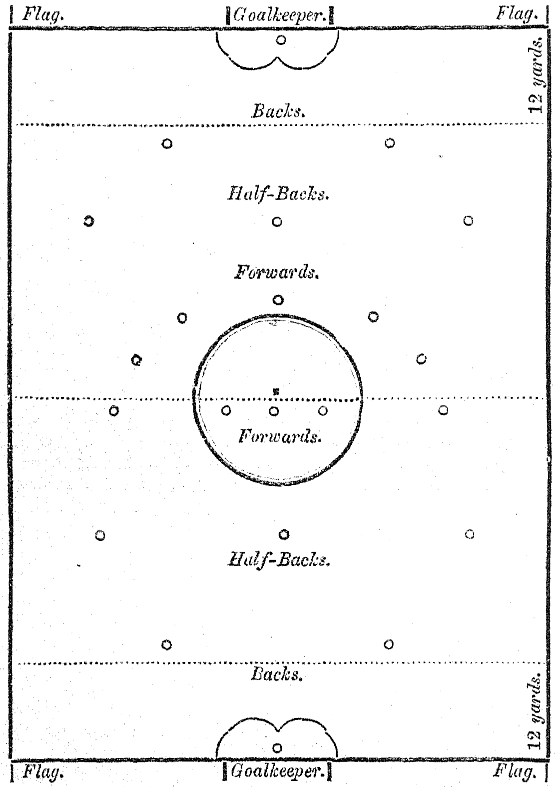
The ball used in Association football is not oval, like that of the Rugby game, but *round*. This obviously secures greater accuracy in kicking, and makes a more directly scientific game possible. This ball, which is made of India-rubber inflated and covered with strongly sewn leather-case, tightly laced, must be between 27 and 28 inches in circumference, and when put upon the ground for play dry, between 13 and 15 ounces in weight. A large field, common, or park forms the most suitable sort of place for a regular competitive game. The most competent authorities agree that the football field should be laid out as shown on next page, and have either the dimensions under-given, or proportionals of them such as may best answer in the space available. The law of the Association requires that "The limits of the ground shall be—maximum *length*, 200 yards; minimum length, 100 yards; maximum *breadth*, 100 yards; minimum breadth, 55 yards. The length and breadth shall be marked off with flags" (1). It is imperative to have "the touch and goal lines clearly defined," and therefore the field of play is usually lined off with whiting or sawdust when the touch and goal lines are not permanently cut on specially prepared or private club-grounds. At each corner of the field a flag-staff or post, not less than 5 feet high, with a flag on it, should be placed. "The centre of the ground shall be indicated by a suitable mark." A line

is drawn across the field at twelve yards' distance from each goal. In the event of any player on the defending side tripping, pushing, or back-charging any of the opponent players between this line and the goal, a penalty-kick is awarded to the attacking side. The kick thus awarded may be taken from any point in the 12 yards' line, and all players on either side, except the defending goal-keeper and the kicker-off, must be at least 6 yards nearer the centre of the field than the 12 yards' line until the ball is kicked. Even the goal-keeper must stand at 6 yards' distance from the ball. "A line defining the 6 yards from the goal-posts shall, it is enacted, also be marked out." "The goals shall be upright posts, placed 24 feet apart, and have a bar across them 8 feet from the ground, and to win a goal the ball must pass *between* the goal-posts *under* the bar." The object of the opposing teams of players is the same as in all football—to drive

A PLAN OF AN ASSOCIATION FOOTBALL FIELD,

INDICATING POSITION OF PLAYERS ON EACH SIDE.

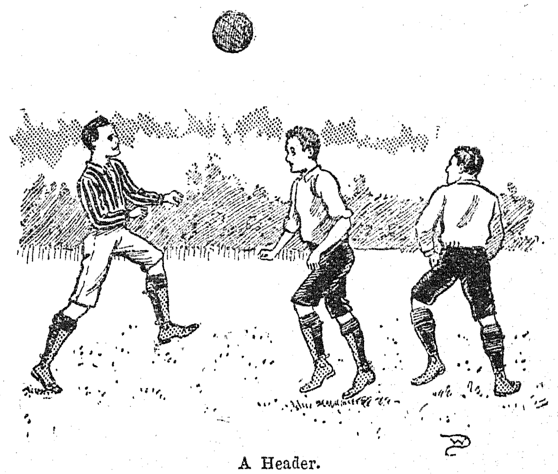
55 to 100 *yards.*



Goal, 24 *feet* wide and 8 *feet* high.
Length of Field, 100 to 200 *yards.*
Radius of Centre Circle, 10 *yards.*

the ball into their rivals' portion of the field and to force for it a passage through their goal. The number of each *team* is *eleven.* One of these is captain of the players and director of the game on his side. The members of each team are usually arranged thus: *five* forwards, *three* half-backs, *two* backs, and *one* goal-keeper. Their places on the field are ordinarily those shown in the above diagram, viz., the up-players, to whom the right of kick-off has fallen, bring their forwards towards the *centre* of the field—through which a centre line has been drawn, and round the mid-point of which a circle, having a radius of 10 feet, has been described. At the centre the ball is placed ready for the kick-off. Along the central line the forwards range themselves, *three* within the circle and *one* on each side of it, or the wings. Immediately beyond the circle the *three* half-backs extend themselves, and at a little distance in front of the goal-line, which is 12 yards from the lines of goal, the two backs station themselves, and the goal-keeper as custodian of the goal. Their opponents being prohibited by rule from being nearer the ball to be kicked off than 10 yards, dispose themselves round but outside of the upper segment of the centre-circle, their half-backs, backs, and goal-keeper taking similar relative places behind them to those occupied by their rivals. The kick-off must be made in the direction of the goal of the opponents of the kicker, and cannot be played back towards his own goal. In the case of the ball going out at the side of the field, and so being put out of play, great care requires to be taken in the act of *throwing in—i.e.,* its being returned to the field and restored to *in play.* This must be done by one of the players on the side opposite to that of the player who put it out. The throw can be made in any direction the thrower chooses, but he must face the field directly, keep both his feet on the side-line, and project the ball with both hands over his head into the field. When a ball goes over the line at the goal-end of the field, if it was last played by the attacking side, a goal kick is awarded—*i.e.,* a place kick taken by one of the defending side from any point within 6 yards of the goal; but, if last played by the defending party, a corner kick is awarded. This is a place kick taken by one of the attacking side from a point distant less than *one* yard from the nearest corner-flag. Should the ball be kicked beyond the goal-line and so go into touch in goal, very much the same thing requires to be done.

Heading.—The "header" is useful both for preventing and obtaining a goal. A back who is a good header may be the means of saving his goal when the ball is too high to be kicked. In the same way a forward may, by catching it with his head, convert into a goal what would otherwise have been only a goal kick. Of course heading may be indulged



A Header.

in at any time, but its usefulness is most seen when a free or a corner kick has been awarded, as then, if the players understand each other, the kicker may raise the ball so as to enable the header, who is waiting the opportunity, to place it into goal, and the movement is generally so quick that the goalkeeper seldom has a chance to save it.

The respective duties of the members of each team are as follows, viz.—

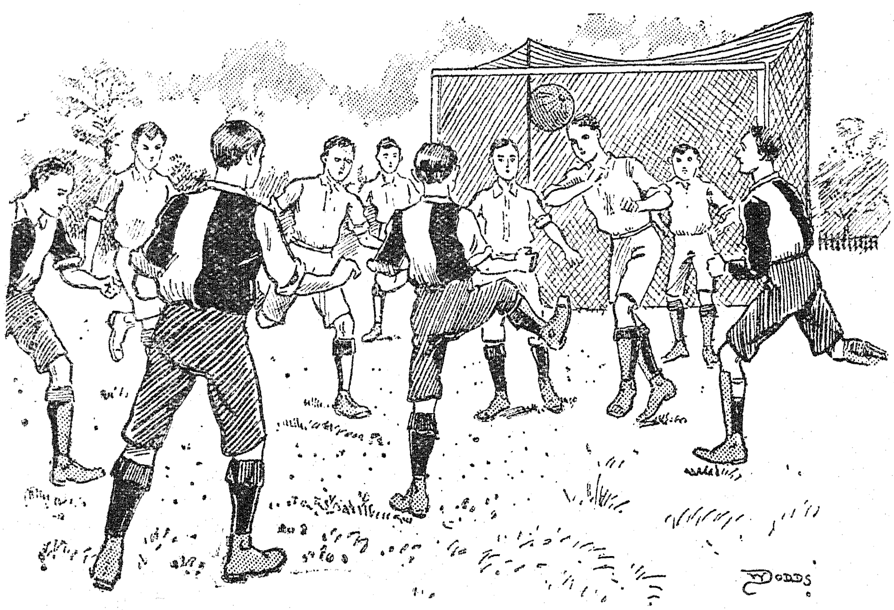
1. *Goalkeeper.*—This player is the guardian of the garrison; his position is *in* goal, and his duty is to defend the goal and by all right means to keep the ball from getting through it. He is the only player on his side who is allowed to use his hands in playing the ball. He may punch, catch, hold, throw, or kick—but must not carry the ball. Going *two* yards with the ball in his hand is reckoned carrying, and the penalty imposed for such an act is the granting of a free-kick to the opposing side.

2. *Backs.*—Of these there are *two.* They stand in front of the goalkeeper, whose assistants they are in defending the goal against their assailants; and their duty is to play their best for that purpose. They tackle the forwards of their

opponents, deprive them, if possible, of the ball, and drive it back towards their opponents' goal.

3. *Half-backs.*—There are *three* half-backs. Their position is in front of the backs. Their part in the game is to tackle the opposing forwards and play in the ball from them towards their own forwards, so as to enable them by individual dribbling or combined passing to take the ball towards their opponents' goal, and of course assist the backs in resisting the invasion of their own goal.

4. *Forwards.*—The *five* forwards are generally thus disposed:—*One* in the centre—the centre forward; *two* on his right—the right wing; and *two* on his left—the left wing. The forwards are the main fighting forces of their own side —the leaders in the attack or defence as the case may be.



Defending the Goal.

Their business is to gain or retain the ball in the due course of the play, and so to manage it by skilful personal effort and combined adroitness of foot to outwit the opposing party and to propel it forwards through their ranks, until it passes fairly and safely through the goal defended by their rivals. Their feet should be nimble and trusty; their kicking smart yet safe; their tactics not dodgy but varied; their passing well-timed and neat; their charging brisk, even brusque but not ill-natured, and their following up close and mutually helpful, yet careful in avoiding off-side or other penalties. Proficiency in the art of dribbling and passing, dexterity in playing to wing or centre, in evading antagonists and working into the way of colleagues without collision, deftness in flexure of ankle, sureness and force of foot in kicking give gusto to the game. Dribbling, though always pretty to look at, is not now so much countenanced by the leading

Dribbling.

clubs, as it tends to selfishness among the players when combination is what is wanted off them. At the same time a good dribbler, who should also be a swift runner and a good goal-scorer, may be very effective, and may be the means of obtaining goals by his own exertions that could not be got by combination. Sometimes from the very moment of the kick-off the ball is driven on towards the opponents' goal. It would seem as if victory was certain: the half-backs are passed, the backs appear likely to be evaded, and then only the goalkeeper will require to be overcome. But an expert kick from a back turns its course to the centre again. Furious attack and fierce defence alternate—

fortune wavers as to which will win, and the excitement increases. Skill and strength are exerted on each side to the utmost. Then it goes beyond the power of the backs to keep it from the goal, the goalkeeper may succeed in warding off the threatening defeat, and anew the warfare is waged. But at last a goal is achieved or half-time is called; and, sides being changed, the fight is renewed. When, however, two renowned teams meet in contest, the play may continue with such incessant come and go, that the ball is never got to goal at all during the whole allotted time of an hour and a half. Contrariwise it has occasionally happened that four goals have been scored in ten minutes, three in seven minutes, and a score of three goals has even been made in four minutes.

No hacking—*i.e.* intentional kicking—or hacking over, or tripping is allowed, and no player is at liberty to use his hands or arms for holding back or pushing over an adversary. All charging should be done with a full front and not

Charging.

from behind, unless a player is standing with his back towards his opponents' goal, and even then his adversary "must not charge by leaping upon him" (14).

As, in the Association game, no holding, pushing, tripping, hacking, or carrying (except in the two yards licence of the goalkeeper) is allowed, any breach of the rules upon these points being reckoned a "foul" or fault, on the commission of which a free kick is awarded to the opponents of the defaulter's side, the play is much simplified and less dangerous. Again, as no scrummages take place, onlookers can see the skill of foot displayed by the players throughout the entire course of the game, and follow it with knowledge and interest, while the players themselves run less risk of injury. Hence the game is generally more rapidly finished, with less fatigue to the players and probably less tedium to the spectators.

It may be useful to readers of notices of athletic sports, as well as to players in them, so we shall now present a brief analysis of those Association rules which are similar—or very nearly so—to the Rugby ones:—Law 1 regulates "the limits of the ground" and the structure of the goals; 2 enacts the method in which the game is to be begun; and 3 determines how and when "ends shall be changed" and nearly coincides with Rugby's 39 and 4. The manner in which "a goal shall be won" is declared in 4, which is almost equivalent to Rugby 5. When the ball goes "in touch," 5 decides how it is to be treated, and 6 the conditions to be observed in playing it—these may be compared with Rugby 31-35. Similar instructions are in 7 given regarding the ball in "touch in goal;" and Rugby 21, 41, and 42 deal with the same subject. Carrying, knocking on, and handling the ball are prohibited, except under circumstances stated in 8; tripping or hacking in 9; in 10 the kind of feet-gear disallowed is described; and 16 provides that "in the event of any infringement of rules 2, 5, 6, 8, 9, or 10 a free kick shall be forfeited to the opposite side from the spot where the infringement took place. Such infringements are called "fouls."

The following "Definition of Terms" is subjoined to the Association Rules:—*Hacking*, kicking an adversary intentionally. *Handling*, playing the ball with hand or arm. *Holding*, the obstruction of a player by the hand or any part of the arm extended from the body. A *Place Kick* is a kick at the ball when it is on the ground, in any position in which the kicker may choose to place it; and a *Free Kick* is similarly placed, so that "when it is lying on the ground none of the kicker's opponents are allowed to be within 6 yards of the ball; but in no case can a player be forced to stand behind his own goal-line." *Knocking on* is when a player strikes or propels the ball with his hands or arms. *Tripping* is throwing an adversary by the use of the legs. To these definitions we may add the following, which are implied in the regulations:—*In touch*, beyond the field boundaries. *Kick-off*, a place-kick made from the centre of the ground at the commencement of a game. *In play* is said (1) of a ball which is fairly in the field, and (2) of a player who is strictly following up in accordance with the rules. *Out of play* is said of a ball which is *in touch*, until it has been thrown in, and of a player when he is nearer the opponents' goal than such a ball thrown in; or who is in any way before the ball while it is being played towards the opponents' goal, unless there are three or more of his opponents nearer their own goal line than he is; or who is nearer to a ball, that is in place for being kicked, than six yards, unless it is being kicked from the goal-line. A *Corner-flag Kick* is one given by a player of the opposite side to any other who has kicked the ball behind his own goal-line.

While many admire football as an excellent means of developing physical strength, endurance, and activity, they regret its tendency towards accidents and bruises. An endeavour has recently been made to introduce a substitute which may retain most of the recreative qualities of that game, yet avoid the greater part of the dangers and risks attending it. It is played like Association football, by eleven on a side —five forwards, three half-backs, two full backs, and a goal-keeper—on grounds 100 yards long and 50 wide; borders of the longer length are called *side*-lines and the shorter ones *goal*-lines. The goals may, by agreement, resemble either the Rugby or the Association ones. The object of the game is that each team should make as many goals as possible by driving the ball through their rivals' goal in two half-games, each of thirty-five minutes' duration, seventy minutes in all. The ball shall average in circumference between 27 and 28 inches. This ball is to be played by a racquet, which shall not exceed 4 feet in length, and the unfilled-in oval throwing end 14 inches long and 7 wide. With this racquet the ball may be dribbled, passed, and thrown, but not carried. Even if the ball should be caught in the oval of the racquet, it must be instantly set free, and neither hands, head, feet, nor any part of the body, should be used to propel the ball. No goal obtained in any other than by fair racquet play can be counted as won. It is not permissible for any player with racquet or otherwise to hold, trip, push, shoulder, punch, charge, or try to overthrow an opponent; nor shall any one attempt to strike the ball across the body of any player

having possession of the ball. Such offences place the players "offside." If any player attempts to put the ball through the opponents' goal when there are less than three of the opponents between him and the goal when he begins to play the ball, is deemed "offside," and his play is disallowed. The winner of the toss shall start the game by playing the ball from the centre of the field—none of the players on his own side being in advance of him, nor any of the opponents' players nearer the ball than 5 yards. If the ball is by any one played beyond the side lines, a throw-in, in any direction, will be given to the opposite side; and if a player pass the ball over the goal-lines, a corner throw-in from the angles of the side goal-lines—no player being nearer than 5 yards to the thrower-in. Should any intentional breach of any of the rules of the game be committed, a *free shy* at goal shall be allowed the opposite side from the place at which the infringement occurred—the 5 yards' distance rule being acted upon. The inventor of "the game of goal-ball," A. Alexander of Liverpool, claims that in it "the ball can be dribbled faster than in football, passed more accurately than in hockey, thrown more easily and distinctly than in lacrosse, while the shooting at goal is more certain and frequent than in Association and Rugby." He commends it as a game valuable for improving and preserving physical strength, and, while culturing skill, interesting spectators and giving pleasure to players.

Some of the wisest advocates of recreative sport—concerned more about health and enjoyment than prizes and profit—have long felt that if football, like cricket, were made a game having a universally recognized code of accepted laws and regulated practice, its utility and advantage as an amusement would be much increased, and think that few things could more conduce to the success of this aim than the preparation of a plain and easy directory for the game, arranged in a progressive series, in which beginners could play (1) a preliminary or elementary game, involving the knowledge and practice of kicks and catches, dribbling and passing, runs and tries, and the less intricate modes of gaining goals; (2) an intermediate or secondary game, bringing into the field some of the finer peculiarities of play—*e.g.* the stricter regulations of touch, wing, and central play, and a more definite fixing and arrangement of the fielding; and (3) a match and club game *par excellence*, incorporating in its play the full scientific method with all its definitions, rules, styles, &c., acknowledged and operative—yet the whole three forming a connected educative scheme, each part trained for joining, on due proof of efficiency, the higher divisions of the football course of study and practice, which would enable the players to take part in this fine national open-air pastime, anywhere they might be, in their own grade of the game. This a well-chosen committee of the members of the Rugby Union and of the Football Association might advantageously plan and propose, and thus supply the best possible foundation for a progressive recreative football, which might be sanely recreative, yet, if thought desirable, would afford scope for (1) taking honours by amateurs and (2) exhibiting the skill and mastery of professionalism.

CHAPTER V.

CRICKET—SINGLE AND DOUBLE WICKET.

Dean Hole of Rochester claimed for cricket "priority over all other games"—as "a manifestation of strength under the control of science," as "a triple alliance of eye, hand, and brain," and "for that marvellous, precise, subtle power which was given to the hand and wrist" by it. Few games have attained so high a place in popular regard, and so beneficially link together recreation and education. Cricket is as highly valued as a summer amusement as football is as a winter game. It is now-a-days not only the great national pastime of England, but has been adopted by countries over sea, and flourishes everywhere it goes, as a finely organized form of practical physical culture such as has never been excelled in quality.

Everybody need not know the *genesis* of cricket nor the ancient history of the game, the songs that are sung, the tales that are told, the sayings and doings of cricket dons, or the epic in which it is glorified; but all should know and possess the laws codified originally by the Marylebone Club in 1784, and which remain as the statutes and ordinances of cricketers, though with successive modifications in small details found to be advisable in the changed circumstances of the times, and in the experience of those who know and see most of the results of the playing alike in batting, bowling, wicket-keeping, and fielding. The secrets of cricket craft are only able to be learned by close observation and sedulous practice; watch well, reflect carefully, exercise tirelessly and under critical eyes if possible, take notes as to successes and non-successes and the probable causes of each, observe the laws of health and good humour, study the rules of the game thoroughly, and whether at single or at double wicket you will not only have but give pleasure at the wicket or in the field. A good game well played is the foe of gloom.

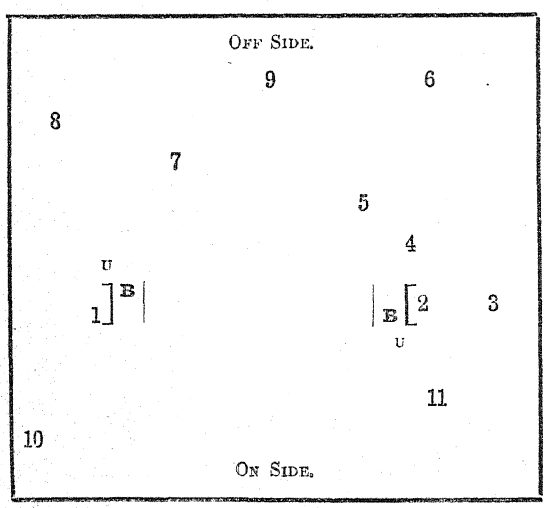
Cricket is played in two forms—I. *Single Wicket*, in which there is used one of each of the following requisites—viz. ball, bat, and wicket, a bowling crease, and a popping crease. At it any number of players not exceeding seven or eight, arranged in two sides, may play. II. *Double Wicket*, which is played with *two* balls, bats, and wickets, two bowling creases, and two popping creases. The players form two sides, of which one shall consist of eleven, but the other—though usually confined to the same number—may be extended to any number mutually agreed upon. The laws of single wicket are much fewer and simpler than those fixed for double wicket.

The laws of *Single Wicket* are as follows:—(1) "When there shall be less than five players on a side, bounds shall be placed distant 22 yards each, in a line, from the *off* and the *leg* stump." (2) "The ball must be hit before the bounds to entitle the striker to a *run*, which run cannot be obtained unless he touch (*a*) the bowling stump, or (*b*) the bowling crease, in a line with his bat or some part of his person, or go beyond them" [*i.e.* the bowling crease or the stump], "returning to the popping crease, as at double wicket according to law xxi.," which enjoins that if "in running, the wicket be struck down by a throw, or by the hand or arm (with ball in hand) before his [the runner's] bat in hand, or some part of his person, be grounded over the popping crease," the runner shall be "out." (3) "When the striker shall hit the ball, one of his feet must be on the ground and behind the popping crease, otherwise the umpire shall cry No hit." (4) "When there shall be less than five players on a side, neither *byes* nor *overthrows* shall be allowed, nor shall the striker be caught out behind the wicket, nor stumped out." (5) "The fieldsman must return the ball so that it shall (*a*) cross the play between the wicket and the bowling stump, or (*b*) between the bowling stump and the bounds—the striker may run till the ball be so returned." (6) "After the striker shall have made one run, if he start again, he must touch the bowling stump and turn, before the ball cross the play, to entitle him to another run." (7) "The striker shall be entitled to three runs for 'lost ball,' and the same number for ball stopped with bat, with reference to laws xxviii. and xxxii."—the former providing that if "more have been run before 'lost ball' shall have been called, then the striker shall have all that have been run," and the latter that "if any be run he shall have five in all." (8) "When there shall be more than four players on a side, there shall be no bounds. All hits, byes, and overthrows shall then be allowed." (9) "The bowler is subject to the same laws as at double wicket, ix.–xiii." [see p. xxiv]. (10) "No more than one minute shall be allowed between the bowling of each ball."

It will be seen that *driving* in front of the wicket must be the main stroke of the single-wicket batsman, as the ball must be hit *before* the bounds—*i.e.* 22 yards each in a line from the stumps. As the striker (by Rule 3) cannot move beyond the popping crease, and must therefore have the ball bowled up to him so far that he can drive it without leaving his ground, he cannot rightly drive a slow ball without going out of his ground. This makes the game rather dull for the players and uninteresting to the onlookers, as compared with a double-wicket one. Hence single wicket is much less frequently

played now than formerly. In country districts where there are few players, and where practice in bowling, batting, and fielding is desired, it should be kept up. Indeed, no one need hope to enter into a cricket team of any note unless he has acquired considerable expertness with ball and bat, and agility in running, catching, and throwing. Cricket practice in country villages and on town commons or public parks may be made very useful in athletic culture, with a little supervision and encouragement.

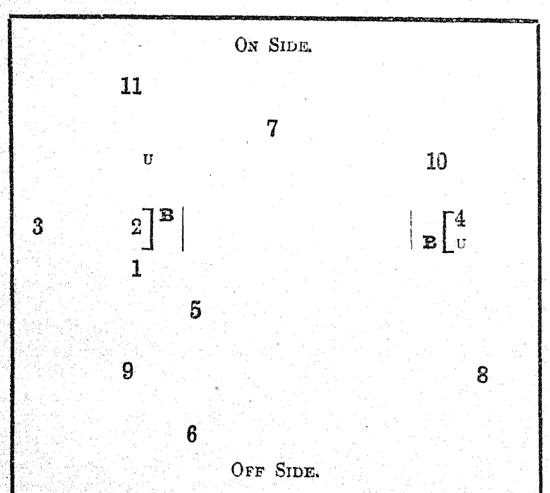
In *Double Wicket* the rules declare that—(1) a match is played between two sides of eleven players each, unless otherwise agreed to; each side has two innings taken alternately—



POSITION OF FIELD FOR FAST BOWLING.

1 Bowler.	4 Short slip.	7 Mid-wicket.	10 Long on.
2 Wicketkeeper.	5 Point.	8 Long off.	11 Leg.
3 Long stop.	6 Long slip.	9 Cover point.	

U U Umpires. B B Batters.



POSITION OF FIELD FOR SLOW BOWLING.

except in the case provided for in law liv., which decrees that "the side which goes in second shall follow their innings if they have scored eighty runs less than the opposite side." On the last day of a match, and in a one-day match at any time, the *in*-side may declare their innings at an end. (2.) The score shall be reckoned by runs. A run is scored—*a*. so often as the batsmen, after a hit, or at any time while the ball is "in play," shall have crossed and made good their ground from end to end; *b*. for penalties under laws xvi., xxxiv., xli., and allowances under xliv., which refer respectively to "no balls" and "wides," "lost ball," "stop ball," and "boundaries." Any runs so scored shall be duly recorded by scorers appointed for the purpose. The side which scores the greatest number of runs wins the match. No match is won unless played out or given up, except in the case provided for in law xlv., which instructs the umpires that "they shall allow *two* minutes for each striker to come in, and *ten* minutes between each innings;" and adds—"When they shall call 'play,' the side refusing to play shall lose the match." [It is further enacted in this connection by law l., that "if either batsman run a short run, the umpire shall call "one short," and the run shall not be scored.]

The disposition of the team and the distribution of its members to their several stations as batsmen, bowlers, wicket-keepers, and fieldsmen fall to be determined by the Captain of the respective sides, or by previous arrangement among the players and agreed to by all parties. The annexed diagrams will give a general idea of the arrangement of the players.

Before the wickets, one at either set, stand the batsmen, B B, who alone of their side are engaged in the game so long as they can keep in. They take guard and block, standing just within the popping creases. It is their duty to preserve their wickets intact, by astute defence, against the endeavours of their opponents to have either of them declared "out" in any of the events circumstantially defined in laws xvi., xxxii. At one of the sets of wickets the bowler appears, places "one foot on the ground behind the bowling creases and within the return crease [law xi.], and having, as he may if he chooses, required the batsman at the wicket from which he is bowling to stand on that side of it which he may direct [law xv.], he proceeds to deliver the ball towards the other set of wickets with the design and duty of hitting it or having it legally hit if he can, and so get the batsman *out*. He, to prevent this, blocks, and so stops the ball with his bat, or so hits the ball, that it is sent flying into some part of the bounds which he thinks is ill-guarded by any of the fielders, and, if he succeeds in this, trying to exchange places with the other batsman, and so scoring a run (or more) before the ball is returned. If the ball should hit the wicket, or if, though hit by the bat, it should be held by some fielder before it touch the ground, or if it should be returned to either end of the pitch, and should hit the wicket before the running batsman has reached the wicket and grounded his bat within the popping crease, he is declared *out*. "Outs" are technically defined by laws xx., xxxii., under special descriptive names, as bowled, caught, stumped, leg before wicket, hit wicket, obstructing the field, hit the ball twice, and handled the ball. Behind the wicket towards which the bowler delivers the ball the wicket-keeper stands. His duty is to stop the ball if it should pass the wicket unhit by the batsman, or, if hit, to receive it when returned by the fielders, and to use it, if possible, to put the striker out. But, by law xiii., if the wicket-keeper shall take the ball for the purpose of stumping before it has passed the wicket, or if he shall incommode the striker by any noise or motion, or if any part of his person be over or before the wicket, the striker shall not be out, except under laws xxvi., xxx. The other fieldsmen are the assistants of the bowler and wicket-keeper to "out" the batsman. A substitute batsman may be allowed under certain conditions, which are defined and stated in laws xxxvi., xl. The balls must be delivered in "overs" of *five* from each wicket alternately. When five balls have been bowled and the ball is finally settled in the bowler's or the wicket-keeper's hands, the umpire shall call "over"—but neither a "no ball" nor a "wide" shall be reckoned as one of the *over*. The same process goes on again till the innings are closed, and the second innings proceed in the same way. Here follow the names, with a note of the respective duties, of the other persons engaged in match-competitions at cricket:—

Umpires.—The duties of the umpires are clearly and strictly defined in rules 6, 14, 36, and 45, and the "Rules" ought always to be at hand for ready reference in case of any dispute regarding their interpretation. The chief qualifications of umpires are—(1) a good knowledge of